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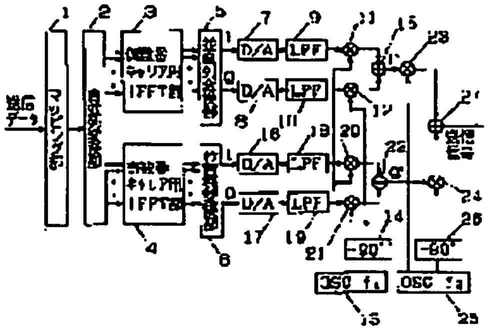
(54) OFDM MODULATOR AND OFDM DEMODULATOR

(57)Abstract:

PURPOSE: To reduce multi-path disturbance without insertion of a guard interval in the OFDM modulation system.

CONSTITUTION: A mapping section 1 forms complex data from transmission data. The complex data are distributed into two series and allocated to each of even nombered orthogonal carrier and odd numberth orthogonal carrier and given to an even numbered carrier IFFT section 3 and an odd numbered carrier IFFT section 4, in which the data are subjected to inverse high speed Fourier transformation in the unit of OFDM symbol and converted into complex data on time base. The complex data on time base with an even numbered carrier subjected to digital modulation are formed into a waveform in which a first half waveform for an OFDM symbol period is excluded and the same waveform as the last half waveform is interpolated to the first half waveform in the demodulator. The complex data on time base of an odd numbered carrier subjected to digital modulation are formed into a waveform in which a first half waveform for an OFDM symbol period is excluded and the same waveform as the last half wave form is inverted and interpolated to the first half waveform in the demodulator.



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CLAIMS

[Claim(s)]
[Claim 1] In the OFDM modulator in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence ~~The serial/parallel-conversion means which distributes a complex data sequence to two~~ sequences, and ~~assigns this each sequence to the even-numbered rectangular carrier and the odd-numbered rectangular carrier,~~ The sequence assigned to the even-numbered rectangular carrier by this serial/parallel-conversion means, And the reverse DFT processing section for No. even carriers and the reverse DFT processing section for No. odd carriers which perform reverse DFT processing, respectively and output the complex data wave on a time-axis to the sequence assigned to the odd-numbered rectangular carrier, The OFDM modulator characterized by having two quadrature modulation machines which carry out quadrature modulation with the output of each of said reverse DFT processing section.
[Claim 2] In the OFDM demodulator in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence Two rectangular demodulators for carrying out the rectangular recovery of the rectangular recovery signal of a No. even carrier, and the rectangular recovery signal of a No. odd carrier, respectively, The wave processing section for No. even carriers which eliminates the wave of the first half for the complex data on the time-axis of the No. even carrier which is obtained by one side of this rectangular demodulator, and by which digital modulation was carried out from the core of an OFDM symbol, and interpolates the wave of the second half, and the same wave in the first half, The FFT processing section for No. even carriers which changes the output of this wave processing section for No. even carriers into the complex data on a frequency shaft, The wave processing section for No. odd carriers which eliminates the wave of the first half for the complex data on the time-axis of the No. odd carrier which is obtained by another side of said rectangular demodulator, and by which digital modulation was carried out from the core of an OFDM symbol, reverses the polarity and interpolates the wave of the second half, and the same wave in the first half, The FFT processing section for No. odd carriers which changes the output of this wave processing section for No. odd carriers into the complex data on a frequency shaft, The OFDM demodulator characterized by having a parallel-serial conversion means to change into the complex data sequence on a series-connected-type-type frequency shaft the complex data sequence on two parallel frequency shafts acquired from said two FFT processing sections.
[Claim 3] In the OFDM modulator in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence The serial/parallel-conversion means which distributes a complex data sequence to two sequences, and assigns this each sequence to the even-numbered rectangular carrier and the odd-numbered rectangular carrier, The sequence assigned to the even-numbered rectangular carrier by this serial/parallel-conversion means, And the reverse DFT processing section for No. even carriers and the reverse DFT processing section for No. odd carriers which perform reverse DFT processing, respectively and output the complex data wave on a time-axis to the sequence assigned to the odd-numbered rectangular carrier, the two 1st quadrature modulation machines which carry out quadrature modulation of the carrier of the 1st frequency with the output of each of said reverse DFT processing section -- this -- the OFDM modulator characterized by having the 2nd quadrature modulation machine which carries out quadrature modulation of the carrier of the 2nd frequency with each output of the two 1st quadrature modulation machines.
[Claim 4] In the OFDM demodulator in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence The 2nd rectangular demodulator for carrying out the rectangular recovery of the input signal on the carrier of the 2nd frequency, this -- the rectangular recovery signal of a No. even carrier and the rectangular recovery signal of a No. odd carrier which are acquired by the 2nd rectangular demodulator on the carrier of the 1st frequency with the 1st two rectangular demodulator which carries out a rectangular recovery, respectively this -- with the wave processing section for No. even carriers which eliminates the

wave of the first half for the complex data on the time-axis of the No. even carrier which is obtained by one side of the 1st rectangular demodulator, and by which digital modulation was carried out from the core of an OFDM symbol, and interpolates the wave of the second half, and the same wave in the first half The FFT processing section for No. even carriers which changes the output of this wave processing section for No. even carriers into the complex data on a frequency shaft, The wave processing section for No. odd carriers which eliminates the wave of the first half for the complex data on the time-axis of the No. odd carrier which is obtained by another side of said 2nd rectangular demodulator, and by which digital modulation was carried out from the core of an OFDM symbol, reverses the polarity and interpolates the wave of the second half, and the same wave in the first half, The FFT processing section for No. odd carriers which changes the output of this wave processing section for No. odd carriers into the complex data on a frequency shaft, The OFDM demodulator characterized by having a parallel-serial conversion means to change into the complex data sequence on a series-connected-type-type frequency shaft the complex data sequence on two parallel frequency shafts acquired from said two FFT processing sections.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the OFDM modulator and OFDM demodulator in the OFDM modulation technique which carries out digital modulation of two or more rectangular carriers by complex data.
[0002]
[Description of the Prior Art] The orthogonal frequency division multiplex method (it is called "OFDM" Orthogonal Frequency Division Multiplexing and the following.) which divides into two or more sequences the data which should be transmitted, and carries out digital modulation of two or more rectangular carriers according to each divided data sequence, respectively is learned. Since this modulation technique is rectangular frequency spectrum, its frequency use effectiveness is good, and since 1 symbol time amount is long, it is strong to multi-pass active jamming. Since it has such features, use to digital terrestrial broadcasting or digital mobile communications is considered.
[0003] Drawing 7 is an explanatory view explaining the conventional OFDM modulator. the inside of drawing, and 80 -- the mapping section and 81 -- the serial/parallel-conversion section and 82 -- the IFFT section and 83 -- for the LPF section, and 88 and 89, as for the oscillation section and 91, the multiplication section and 90 are [a D/A transducer, and 86 and 87 / a parallel series transducer, and 84 and 85 / the phase shift section and 92] adder units. As a digital modulation method for modulating each rectangular carrier, although it is easy to be the thing of arbitration, this conventional example shows the example using quadrature modulation methods generally adopted, such as QPSK and 16QAM. Theoretically, it can replace with a digital modulation method and an analog modulation method can also be used.
[0004] Transmit data is inputted into the mapping section 80, and the complex data which consist of inphase shaft (i) data which specify the amplitude to a rectangular carrier and relative topology for digital modulation, and orthogonal-axis (q) data are formed. This complex data is changed into a number equal to the number of the rectangular carriers which constitute OFDM of complex data aggregates (henceforth an "OFDM symbol") in the serial/parallel-conversion section 81. Each complex data which constitutes an OFDM symbol is assigned to two or more rectangular carriers according to an individual. This OFDM symbol is inputted into the IFFT section 82 which is the reverse fast-Fourier-transform section. The IFFT section 82 outputs the wave signal which digital modulation is carried out with the complex data with which each amplitude and phase of a rectangular carrier correspond, and is acquired. This wave signal is outputted in the form of the complex data on a time-axis in that case. The complex data on this time-axis express the wave (henceforth a "I signal") of the inphase component of a data point and the wave (henceforth a "Q signal") of an orthogonal component which digital modulation is carried out and are acquired. Although the complex data on the time-axis outputted from the IFFT section 82 are outputted to juxtaposition as data for every two or more:00 point on a time-axis, they are changed by the parallel series transducer 83 and serve as complex data on the time-axis of a series-connected-type type, an I signal, and a Q signal.
[0005] An I signal and a Q signal are changed into an analog signal by the D/A transducers 84 and 85, and are inputted into the multiplication sections 88 and 89 through the LPF sections 86 and 87 which are low pass filters, respectively. In the multiplication section 88, the multiplication of the sequence of an I signal should be carried out to the output of the oscillation section 90, and the phase shift should be multiplication-carried out by the sequence of a Q signal -90 degrees in the output of the oscillation section 90 by the phase shift section 91 in the multiplication section 89. Each output by which multiplication was carried out is added in an adder unit 92, and the sending signal by OFDM is outputted. In addition, the oscillation section 90 generates the carrier of the frequency f1 of a radio frequency band or an intermediate frequency band.
[0006] The case where digital modulation of the rectangular carrier is carried out for an example of actuation of the

OFDM modulator shown in drawing 7 using QPSK is explained.

[0007] Drawing 8 is an explanatory view explaining symbol mapping of a QPSK modulation technique. For 43, as for the 2nd coordinate point of a symbol, and 45, the 1st coordinate point of a symbol and 44 are [the 3rd coordinate point of a symbol and 46] the 4th coordinate point of a symbol among drawing. The orthogonal axis of the phase to which the inphase shaft of the phase of a carrier and an inphase and an axis of abscissa cross at right angles, and the phase of a carrier and an axis of ordinate cross at right angles is expressed. About the complex data at the time of using QPSK, it is the following and QPSK symbol Qk. It says. It sets in the mapping section 80 and is transmit data Sk. QPSK symbol Qk which corresponds and expresses the coordinate of four symbols on the unit circle of a radius 1 It is outputted. For example, it is divided into 2 bits at a time (Sk and Sk+1), and series-connected-type-type transmit data is Sk. QPSK symbol Qk It corresponds to the coordinate of an inphase shaft (i), and is Sk+1. QPSK symbol Qk It corresponds to the coordinate of an orthogonal axis (q). Consequently, QPSK symbol Qk which expresses the 1st coordinate point 43 of a symbol, the 2nd coordinate point 44, the 3rd coordinate point 45, and the 4th coordinate point 46 corresponding to transmit data (0 0), (0, 1), (1, 0), and (1, 1), respectively It is outputted. QPSK symbol Qk It is expressed with a degree type.

Qk = (1/root2) [(1-2Sk) + (1-2Sk+1)]

And serial QPSK symbol Qk = (Q0, Q1, and Q2, ..., Q199) of 200 is the parallel QPSK symbol of 200, Q0, Q1, and Q2, ..., Q199 by the serial/parallel-conversion section 81. It is changed and becomes one OFDM symbol.

[0008] Be [what is necessary / just although the block of the IFFT section 82 carries out reverse DFT, i.e., the reverse digital Fourier transform,], IFFT, i.e., a reverse fast Fourier transform, is usually used. When setting the number of rectangular carrier signals to 200, the reverse fast Fourier transform which makes a point size the value of 256 which serves as a exponentiation of 2 above this value is performed. In this example of explanation, the QPSK symbol Qk is assigned to 200 points among 256 points, the QPSK symbol corresponding to the 56 remaining points sets to 0, and the rectangular carrier corresponding to this is not transmitted. In addition, generally the QPSK symbol for a synchronization etc. is added.

[0009] Drawing 9 is an explanatory view explaining the arrangement on the frequency shaft of the conventional rectangular carrier. the inside of drawing, the rectangular carrier signal of plurality [104], and the QPSK symbol Qk corresponding to [105] each carrier signal in 107 corresponding to frequency spacing in center frequency and 106 it is . The axis of abscissa of a drawing expresses a frequency and an axis of ordinate expresses amplitude level. Ts is, transmitting spacing, i.e., the OFDM symbol period, of an OFDM symbol. The rectangular carrier signal 104 is arranged by 106 focusing on center frequency 105 at the right and left from the frequency spacing -100 of regular-intervals 1/Ts/Ts to 100/Ts. In this example, the number of the rectangular carrier signals 104 is 200, and, as for the QPSK symbol Qk 107 which is complex data, from Q0 to Q199 is assigned corresponding to each rectangular carrier signal 104. Frequency spectrum when digital modulation of each rectangular carrier is carried out by the QPSK symbol Qk 107 serves as the so-called sinx/x type of curve, and it is set to 0 in the frequency point of a contiguity rectangular cross carrier, and restores to the modulating signal of each rectangular carrier 104, without receiving interference mutually.

[0010] Drawing 10 is an explanatory view explaining the conventional guard interval. As for an effective symbol period and 110, the transmission wave form corresponding to one OFDM symbol Qk in 108 and 109 are [the posterior part of an effective symbol period and 111] guard intervals among drawing. Time Division Multiplexing of the same thing as about 20% of part 110 of the posterior part of the effective symbol period 109 of the transmission wave form corresponding to one OFDM symbol Qk is carried out so that it may be inserted in the guard interval 111 preceded with the effective symbol period 109 as a dummy signal. In addition, this Time Division Multiplexing is performed by the parallel series transducer 83 after processing by IFFT82. A guard interval is set up so that the signal which is overdue and comes according to the multi-pass active jamming in a transmission line at the time of reception may arrive at this guard band interval period 111, and a recovery performs about the effective symbol period 109 except this guard interval period 111 so that it may mention later.

[0011] Drawing 11 is an explanatory view explaining the conventional OFDM demodulator. the inside of drawing, and 120 -- the multiplication section and 121 -- the multiplication section and 122 -- the oscillation section and 123 -- the phase shift section and 124 -- the LPF section and 125 -- for the LPF section and 128, as for the FFT section and 130, the A/D-conversion section and 129 are [the A/D-conversion section and 126 / the serial/parallel-conversion section and 127 / a parallel series transducer and 131] the reverse mapping sections. The input signal of OFDM should be inputted into the multiplication section 120 and the multiplication section 121, multiplication should be carried out to the output of the oscillation section 122 in the multiplication section 120, and the phase shift should be multiplication-carried out -90 degrees in the output of the oscillation section by the phase shift section 123 in the multiplication section 121. The output of the multiplication section 120 is inputted into the serial/parallel-conversion section 126 as an I signal through the LPF section 124 and the A/D-conversion section 125 which are a low pass filter. The output of the multiplication section 121 is inputted into the serial/parallel-conversion section 126 as a Q signal through the LPF section 127 and the A/D-conversion section 128. The output of the serial/parallel-conversion section 126 is inputted into the FFT section 129, a fast Fourier transform is performed to it, it is inputted into the parallel series transducer 130, serves as a serial signal, it is inputted into the reverse mapping section 131, and received data are obtained. Be [what is necessary / just although the block of the FFT section 129 carries out DFT, i.e., the digital Fourier transform,], FFT, i.e., a fast Fourier transform, is usually used.

[0012] An example of actuation of the conventional OFDM demodulator shown in drawing 11 is explained about the case where digital modulation of the rectangular carrier is carried out by QPSK. A recovery serves as a reverse process at the time of a modulation mostly. In the multiplication sections 120 and 121, on a frequency f1, a rectangular recovery is carried out and an input signal is divided into the complex signal on the time-axis of a series-connected-type type. These become the complex data, I signal, and Q signal on a time-axis through the LPF sections 124 and 127 and the A/D-conversion sections 125 and 128. This I signal and Q signal are parallelized in the serial/parallel-conversion section 126, in the FFT processing section 129, FFT processing of 256 points is performed, and they are changed into the complex data on a frequency shaft, and serve as an OFDM symbol. This OFDM symbol is the QPSK symbol Qk which is complex data which consist of inphase shaft (i) data and orthogonal-axis (q) data. It is gathering. In that case, the part of the guard interval 111 in an OFDM symbol is disregarded, and FFT processing of the 256 remaining points is carried out. The complex data Q0 which constitute an OFDM symbol, and Q1, ..., Q199 It is changed into complex series-connected-type-type data in the parallel series transducer 130, and the same received data as the original transmit data are obtained in the reverse mapping section 131.

[0013] However, since time base compaction of the effective OFDM symbol period 109 will be carried out as a result of inserting the guard interval 111, breadth and the use effectiveness of a frequency fall [rectangular carrier spacing on a frequency shaft]. Moreover, since the orthogonality of each carrier on a frequency shaft will collapse, the rectangular carrier by which digital modulation was carried out will receive interference mutually.

[0014]

[Problem(s) to be Solved by the Invention] This invention was made in view of the situation mentioned above, and aims at offering the modulator and demodulator which can reduce multi-pass active jamming, without inserting a guard interval between effective symbol periods in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence.

[0015]

[Means for Solving the Problem] This invention is set to invention according to claim 1. In the OFDM modulator in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence The serial/parallel-conversion means which distributes a complex data sequence to two sequences, and assigns this each sequence to the even-numbered rectangular carrier and the odd-numbered rectangular carrier, The sequence assigned to the even-numbered rectangular carrier by this serial/parallel-conversion means, And the reverse DFT processing section for No. even carriers and the reverse DFT processing section for No. odd carriers which perform reverse DFT processing, respectively and output the complex data wave on a time-axis to the sequence assigned to the odd-numbered rectangular carrier, It is characterized by having two quadrature modulation machines which carry out quadrature modulation with the output of each of said reverse DFT processing section.

[0016] In the OFDM demodulator in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence in invention according to claim 2 Two rectangular demodulators for carrying out the rectangular recovery of the rectangular recovery signal of a No. even carrier, and the rectangular recovery signal of a No. odd carrier, respectively, The wave processing section for No. even carriers which eliminates the wave of the first half for the complex data on the time-axis of the No. even carrier which is obtained by one side of this rectangular demodulator, and by which digital modulation was carried out from the core of an OFDM symbol, and interpolates the wave of the second half, and the same wave in the first half, The FFT processing section for No. even carriers which changes the output of this wave processing section for No. even carriers into the complex data on a frequency shaft, The wave processing section for No. odd carriers which eliminates the wave of the first half for the complex data on the time-axis of the No. odd carrier which is obtained by another side of said rectangular demodulator, and by which digital modulation was carried out from the core of an OFDM symbol, reverses the polarity and interpolates the wave of the second half, and the same wave in the first half, The FFT processing section for No. odd carriers which changes the output of this wave processing section for No. odd carriers into the complex data on a frequency shaft, It is characterized by having a parallel-serial conversion means to change into the complex data sequence on a series-connected-type-type frequency shaft the complex data sequence on two parallel frequency shafts acquired from said two FFT processing sections.

[0017] In the OFDM modulator in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence in invention according to claim 3 The serial/parallel-conversion means which distributes a complex data sequence to two sequences, and assigns this each sequence to the even-numbered rectangular carrier and the odd-numbered rectangular carrier, The sequence assigned to the even-numbered rectangular carrier by this serial/parallel-conversion means, And the reverse DFT processing section for No. even carriers and the reverse DFT processing section for No. odd carriers which perform reverse DFT processing, respectively and output the complex data wave on a time-axis to the sequence assigned to the odd-numbered rectangular carrier, the two 1st quadrature modulation machines which carry out quadrature modulation of the carrier of the 1st frequency with the output of each of said reverse DFT processing section -- this -- it is characterized by having the 2nd quadrature modulation machine which carries out quadrature modulation of the carrier of the 2nd frequency with each output of the two 1st quadrature modulation machines.

[0018] In the OFDM demodulator in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence in invention according to claim 4 The 2nd rectangular demodulator for carrying out the rectangular recovery of the input signal on the carrier of the 2nd frequency, this -- the rectangular recovery signal of a No. even carrier and the rectangular recovery signal of a No. odd carrier which are acquired by the 2nd rectangular demodulator on the carrier of the 1st frequency with the 1st two rectangular demodulator which carries out a rectangular recovery, respectively this -- with the wave processing section for No. even carriers which eliminates the wave of the first half for the complex data on the time-axis of the No. even carrier which is obtained by one side of the 1st rectangular demodulator, and by which digital modulation was carried out from the core of an OFDM symbol, and interpolates the wave of the second half, and the same wave in the first half The FFT processing section for No. even carriers which changes the output of this wave processing section for No. even carriers into the complex data on a frequency shaft, The wave processing section for No. odd carriers which eliminates the wave of the first half for the complex data on the time-axis of the No. odd carrier which is obtained by another side of said 2nd rectangular demodulator, and by which digital modulation was carried out from the core of an OFDM symbol, reverses the polarity and interpolates the wave of the second half, and the same wave in the first half, The FFT processing section for No. odd carriers which changes the output of this wave processing section for No. odd carriers into the complex data on a frequency shaft, It is characterized by having a parallel-serial conversion means to change into the complex data sequence on a series-connected-type-type frequency shaft the complex data sequence on two parallel frequency shafts acquired from said two FFT processing sections.

[0019]

[Function] In an OFDM modulator, the even-numbered modulated rectangular carrier and the odd-numbered modulated rectangular carrier are transmitted independently. In an OFDM demodulator, 50% of period is not used for a recovery from the head of an OFDM symbol where the wave which delays and reaches from the effective symbol period preceded according to multi-pass active jamming is contained. About the even-numbered modulated rectangular carrier, the even-numbered modulated rectangular carrier and the odd-numbered modulated rectangular carrier interpolate the same thing as 50% of the second half in the first half, and recovers from having the symmetric property of a proper in 1 symbol, respectively. About the odd-numbered modulated carrier, it is made reversed, and the same thing as 50% of the second half is interpolated in the first half, and is restored to a polarity. Since a guard interval is not inserted in a transmitting side while being able to reduce multi-pass active jamming, since the period of the first half which has received multi-pass active jamming is not used for a recovery, while being able to raise frequency use effectiveness, since each carrier serves as perfect orthogonality relation, its each modulated interference between rectangular carriers decreases.

[0020]

[Example] Drawing 1 is an explanatory view explaining one example of the OFDM modulator of this invention. One among drawing the serial/parallel-conversion section and 3 for the mapping section and 2 The IFFT section for No. even carriers, 4 a parallel series transducer, and 7 and 8 for the IFFT section for No. odd carriers, and 5 and 6 A D/A transducer, As for the LPF section, and 11 and 12, 9 and 10 the 1st oscillation section and 14 for the multiplication section and 13 The 1st phase shift section, 15 -- an adder unit, and 16 and 17 -- a D/A transducer, and 18 and 19 -- for an adder unit, and 23 and 24, as for the 2nd oscillation section and 26, the multiplication section and 25 are [the LPF section, and 20 and 21 / the multiplication section and 22 / the 2nd phase shift section and 27] adder units. As a digital modulation method for modulating each rectangular carrier, although it is easy to be the thing of arbitration, this example shows the example which uses quadrature modulation methods, such as QPSK and 16QAM. Theoretically, it can replace with a digital modulation method and an analog modulation method can also be used.

[0021] Transmit data is inputted into the mapping section 1, it is mapped and complex data are formed. This complex data is changed into an OFDM symbol in the serial/parallel-conversion section 2. However, unlike the conventional technique, complex data are divided and distributed to two, an OFDM even number symbol and an OFDM odd number symbol. An OFDM even number symbol is assigned to each of a No. even rectangular cross carrier, and an OFDM odd number symbol is assigned to each of a No. odd rectangular cross carrier. Since the total of a rectangular carrier is generally made [more] than the total of the complex data which constitute an OFDM symbol, complex 0 is assigned to the rectangular remaining carriers to which complex data are not assigned. An OFDM even number symbol is inputted into the IFFT section 3 for No. even carriers, an OFDM odd number symbol is inputted into the IFFT section 4 for No. odd carriers, the reverse fast Fourier transform of the complex assigned to each carrier is carried out per OFDM symbol, respectively, and it is changed into the complex data on a time-axis. The output of the IFFT section 3 for No. even carriers is inputted into the parallel series transducer 5, and serves as the I signal and Q signal which are complex data on the time-axis of a series-connected-type type. Similarly, the output of the IFFT section 4 for No. odd carriers is inputted into the parallel series transducer 6, and serves as the I signal and Q signal which are two or more data on the time-axis of a series-connected-type type. The I signal and Q signal which are the output of the parallel series transducer 5 are changed into an analog wave by the D/A transducers 7 and 8, respectively, and are inputted into the multiplication sections 11 and 12 through the LPF sections 9 and 10 which are low pass filters. In the multiplication section 11, the multiplication of the sequence of an I signal should be carried out to the output of the 1st oscillation section 13 of a frequency f1, and the phase shift should be multiplication-carried out by the sequence of a Q signal -90 degrees in the output of the 1st oscillation section 13 by the 1st phase shift section 14 in the multiplication section 12. Each output by which multiplication was carried out is added in an adder unit 15, and serves as I' signal.

[0022] Similarly, the I signal and Q signal which are the output of the parallel series transducer 6 are changed into an analog wave by the D/A transducers 16 and 17, respectively, and are inputted into the multiplication sections 20 and 21 through a low pass filter 18 and LPF 19. In the multiplication section 20, the multiplication of the sequence of an I signal should be carried out to the output of the 1st oscillation section 13 of a frequency f1, and the phase shift should be multiplication-carried out by the sequence of a Q signal -90 degrees in the output of the 1st oscillation section 13 by the 1st phase shift section 14 in the multiplication section 21. Each output by which multiplication was carried out is added in an adder unit 22, and serves as Q' signal. I' signal was inputted into the multiplication section 23, multiplication should be carried out to the output of the 2nd oscillation section 25 of a frequency f2, Q' signal should be inputted into the multiplication section 24, and the phase shift should be multiplication-carried out -90 degrees in the output of the 2nd oscillation section 25 of a frequency f2 by the 2nd phase shift section 26. The output of the multiplication section 23 and the output of the multiplication section 24 are added in an adder unit 27, and serve as a sending signal. In addition, a guard interval is not inserted in the OFDM modulator of this invention.

[0023] The case where digital modulation of the rectangular carrier is carried out for an example of actuation of the OFDM modulator shown in drawing 1 using QPSK is explained. About symbol mapping, it is the same as that of the case of the conventional technique explained by drawing 8 . transmit data is inputted into the mapping section 1, and changes into serial QPSK symbol Qk = (Q0, Q1, and Q2, ..., Q199) of 200 -- having -- the serial/parallel-conversion section 2 -- the parallel QPSK symbol of 200, Q0, Q1, and Q2 ... and Q199 from -- it is changed into one becoming OFDM symbol. Under the present circumstances, one OFDM symbol is divided into two sets. Here, it is kicked by two, the OFDM even number symbol which consists of even-numbered QPSK symbol QkE= (Q0, Q2, and Q4, ..., Q198), and the OFDM odd number symbol which consists of odd-numbered QPSK symbol QkO= (Q1, Q3, and Q5, ..., Q199), by the group. Furthermore, an OFDM even number symbol is assigned to the even-numbered carrier (the lowest frequency 1/the even times as many carrier as Ts except DC) of the carrier of 200 which transmits, and an OFDM odd number symbol is assigned to it by the odd-numbered carrier (the lowest frequency 1/the odd times as many carrier as Ts except DC).

[0024] Drawing 2 is an explanatory view explaining arrangement of the rectangular carrier to which an OFDM even number symbol is assigned. the inside of drawing, the carrier signal of plurality [30], and the QPSK symbol Qk corresponding to [31] each carrier signal in 33 corresponding to frequency spacing in center frequency and 32 it is . The axis of abscissa of a drawing expresses a frequency and an axis of ordinate expresses amplitude level. Ts is, transmitting spacing, i.e., the OFDM symbol period, of an OFDM symbol. The rectangular carrier signal 30 is arranged by 32 focusing on center frequency 31 at the right and left from the frequency spacing -100 of regular-intervals 2/Ts/Ts to 100/Ts. In this example, the number of the rectangular carrier signals 30 is 100, and, as for the QPSK symbol Qk 33, from Q0 to Q198 is assigned corresponding to each carrier signal 30. Each rectangular carrier is the QPSK symbol Qk like the conventional technique. Frequency spectrum when digital modulation is carried out and digital modulation of each rectangular carrier is carried out serves as the so-called sinx/x type of curve, and is set to 0 in a midpoint with the frequency point of a contiguity carrier, and the frequency point of a contiguity carrier.

[0025] Drawing 3 is an explanatory view explaining arrangement of the rectangular carrier to which an OFDM odd number symbol is assigned. the inside of drawing, the carrier signal of plurality [34], and the QPSK symbol Qk corresponding to [35] each carrier signal in 37 corresponding to frequency spacing in center frequency and 36 it is . The axis of abscissa of a drawing expresses a frequency shaft, and an axis of ordinate expresses amplitude level. Ts is, transmitting spacing, i.e., the OFDM symbol period, of an OFDM symbol. The carrier signal 70 is arranged from **1/Ts by 36 focusing on center frequency 35 at the right and left from spacing 2/the frequency spacing -99 of Ts/Ts to 99/Ts. In this example, the number of the carrier signals 34 is 100, and, as for the QPSK symbol Qk 37, from Q1 to Q199 is assigned corresponding to each carrier signal 34. Frequency spectrum when digital modulation of each rectangular carrier is carried out with complex data like the conventional technique and digital modulation of each rectangular carrier is carried out serves as the so-called sinx/x type of curve, and is set to 0 in a midpoint with the frequency point of a contiguity carrier, and the frequency point of a contiguity carrier.

[0026] Be [what is necessary / just although the block of the IFFT section 3 for No. even carriers carries out reverse DFT, i.e. the reverse digital Fourier transform,], in this one example, IFFT, i.e., a reverse fast Fourier transform, is used. When setting the total of a rectangular carrier signal to 200, the reverse fast Fourier transform which makes a point size the value of 256 which serves as a exponentiation of 2 above this value is performed. In this one example, an OFDM even number symbol is assigned to 100 points among 256 points, the QPSK symbol corresponding to the remaining point sets to 0, and the rectangular carrier corresponding to this is not transmitted. In addition, the even-numbered QPSK symbol for a synchronization etc. may be added, and the QPSK modulation of the rectangular carrier which corresponds by this may be carried out.

[0027] In IFFT3 for No. even carriers, reverse fast-Fourier-transform processing is carried out by 256 points, and an OFDM even number symbol is changed into the complex data of 256 points in a time-axis, is arranged in on a time-axis by the parallel series transducer 5, and is outputted by the series-connected-type formula. That is, the sum (henceforth "OFDM complex even number data") on the time-axis of the No. even rectangular cross carrier in which the QPSK modulation was carried out by the OFDM even number symbol is outputted according to the I signal of real part, and the Q signal of imaginary part. For example, wave x(t) on the time-axis of QPSK symbol QkE= (Q0, Q2, and Q4, ..., Q198) which constitutes an OFDM even number symbol is expressed with a degree type.

xE (t) =sigmak=-100 100 Qk+100 and exp (j2pikt/Ts)

However, k is -100, -98, -4, -2, and 2, 4, ..., 98,100.

[0028] In the modulator which consists of the multiplication sections 11 and 12 and an adder unit 15, quadrature modulation of each sequence of the I signal of OFDM complex even number data and a Q signal is carried out by the carrier of a frequency f1.

[0029] Be [what is necessary / just although reverse DFT is similarly carried out about the block of the IFFT section 4 for No. odd carriers], in this one example, IFFT is used and the reverse fast Fourier transform of POIN is performed in 256. In this one example, an OFDM even number symbol is assigned to 100 points among 256 points, the QPSK symbol corresponding to the remaining point sets to 0, and the rectangular carrier corresponding to this is not transmitted. In addition, the odd-numbered QPSK symbol for a synchronization etc. may be added, and the QPSK modulation of the rectangular carrier which corresponds by this may be carried out.

[0030] In IFFT4 for No. odd carriers, reverse fast-Fourier-transform processing is carried out by 256 points, and an OFDM odd number symbol is changed into the complex data of 256 points in a time-axis, is arranged in on a time-axis by the parallel series transducer 6, and is outputted by the series-connected-type formula. That is, the sum (henceforth "OFDM complex odd number data") on the time-axis of the No. odd rectangular cross carrier in which the QPSK modulation was carried out by the OFDM odd number symbol is generated according to the I signal of real part, and the Q signal of imaginary part. For example, wave x(t) on the time-axis of QPSK symbol QkO= (Q1, Q3, and Q5, ..., Q199) which constitutes an OFDM odd number symbol is expressed with a degree type.

xO (t) =sigmak=-99 99 Qk+100 and exp (j2pikt/Ts)

However, k is -99, -97, .., -3, -1, 1 and 3, .., 97 and 99.

[0031] In the modulator which consists of the multiplication sections 20 and 21 and an adder unit 22, quadrature modulation of each sequence of the I signal of OFDM complex odd number data and a Q signal is carried out by the carrier of a frequency f1. In the modulator which consists of the multiplication sections 23 and 24 and an adder unit 27, quadrature modulation of the I'signal and Q' signal is further carried out on the carrier of a frequency f2.

[0032] In the above one example, the 2nd step of quadrature modulation is given in the modulator with which I'signal and Q' signal consists of the multiplication sections 23 and 24 and an adder unit 27. However, since a recovery which will mention I'signal and Q' signal later in a receiving side if it transmits independently is attained, the 2nd step of this quadrature modulation is only one example for transmitting independently. Since the approach of transmitting two signals independently has various methods as a multiplex transmission system, the multiplex transmission system of arbitration can be used for it, and it can transmit I'signal and Q' signal independently. Since the guard interval is not inserted, each carrier serves as perfect orthogonality relation.

[0033] In addition, although the analog circuit was used for each modulator, it may be realized by digital signal processing. For example, when digital signal processing realizes all modulators, the D/A transducers 7, 8, 16, and 17 are omitted, D/A conversion is carried out to the last of digital signal processing, and a sending signal is outputted.

[0034] Drawing 4 is an explanatory view explaining one example of the OFDM demodulator of this invention. 40 and 41 among drawing the 2nd oscillation section and 43 for the multiplication section and 42 The 2nd phase shift section, In 44 and 45, the multiplication section and 46 the 1st phase shift section and 48 for the 1st oscillation section and 47 The LPF section, In 49, the A/D-conversion section and 50 the LPF section and 52 for the serial/parallel-conversion section and 51 The A/D-conversion section, In 53 and 54, the multiplication section and 55 the A/D-conversion section and 57 for the LPF section and 56 The serial/parallel-conversion section, 58 -- the LPF section and 59 -- for the FFT section for No. even carriers, and 62, as for the wave processing section for No. odd carriers, and 64, a parallel series transducer and 63 are [the A/D-conversion section and 60 / the wave processing section for No. even carriers, and 61 / the FFT section for No. odd carriers and 65] the reverse mapping sections.

[0035] An input signal is inputted into the multiplication section 40 and the multiplication section 41, and multiplication is carried out to the output of the 2nd oscillation section 42 of a frequency f2 in the multiplication section 40, it turns into I' signal, and the output of the 2nd oscillation section 42 serves as [that the phase shift should be multiplication-carried out -90 degrees and] Q' signal by the 2nd phase shift section 43 in the multiplication section 41. This I'signal and Q' signal is equivalent to I'signal and Q' signal in the OFDM modulator explained by drawing 1 . I' signal should be inputted into the multiplication section 44 and the multiplication section 45, multiplication should be carried out to the output of the 1st oscillation section 46 of a frequency f1 in the multiplication section 44, and the phase shift should be multiplication-carried out -90 degrees in the output of the 1st oscillation section 46 by the 1st phase shift section 47 in the multiplication section 45. The output of the multiplication section 44 serves as an I signal which is a digital signal through the LPF section 48 and the A/D-conversion section 49 which are a low pass filter, and is inputted into the serial/parallel-conversion section 50. The output of the multiplication section 45 serves as a Q signal which is a digital signal through the LPF section 51 and the A/D-conversion section 52 which are a low pass filter, and is inputted into the serial/parallel-conversion section 50. This I signal and Q signal correspond to the real part and imaginary part of the OFDM complex even number data explained by drawing 1 , and are changed into the complex parallel-connected-type-type data in the time-axis of 256 points in the serial/parallel-conversion section 50.

[0036] On the other hand, Q' signal which is the output of the multiplication section 41 should be inputted into the multiplication sections 53 and 54, multiplication should be carried out to the output of the 1st oscillation section 46 of a frequency f1 in the multiplication section 53, and the phase shift should be multiplication-carried out -90 degrees in the output of the 1st oscillation section 46 by the 1st phase shift section 47 in the multiplication section 54. The output of the multiplication section 53 serves as an I signal which is an analog signal through the LPF section 55 and the A/D-conversion section 56 which are a low pass filter, and is inputted into the serial/parallel-conversion section 57. The output of the multiplication section 54 serves as a Q signal which is an analog signal through the LPF section 58 and the A/D-conversion section 59 which are a low pass filter, and is inputted into the serial/parallel-conversion section 57. This I signal and Q signal correspond to the real part and imaginary part of the OFDM complex odd number data explained by drawing 1 . It is changed into the complex parallel-connected-type-type data in the time-axis of 256 points in the serial/parallel-conversion section 57.

[0037] The complex parallel-connected-type-type data in the time-axis of 256 points which are the output of the serial/parallel-conversion section 50 It is inputted into the wave processing section 60 for No. even carriers, the wave processing mentioned later is made, and it sets in the FFT processing section 60 for No. even carriers after ****. FFT processing of 256 points is performed, and it is changed into the complex data on a frequency shaft, and becomes the OFDM even number symbol which is the complex data aggregate which consists of inphase shaft (i) data and orthogonal-axis (q) data. The complex data Q0 changed on the frequency shaft, and Q2, ..., Q198 It is inputted into the parallel series transducer 62. On the other hand, the complex parallel-connected-type-type data in the time-axis of 256 points which are the output of the serial/parallel-conversion section 57 In the FFT processing section 64 for the No. odd carriers after the wave processing which it is inputted into the wave processing section 63 for No. odd carriers, and is mentioned later was made FFT processing of 256 points is performed, and it is changed into the complex data on a frequency shaft, and becomes the OFDM odd number symbol which is the complex data aggregate which consists of inphase shaft (i) data and orthogonal-axis (q) data. The complex data Q1 changed on the frequency shaft, and Q3, ..., Q199 It is inputted into the parallel series transducer 62.

[0038] Complex series-connected-type-type data Qk which an OFDM even number symbol and an OFDM odd number symbol are unified in the parallel series transducer 62, and constitutes an OFDM symbol It is changed and the same received data as the original transmit data are obtained in the mapping section 131.

[0039] The case where digital modulation of the rectangular carrier is carried out by QPSK in an example of actuation of the OFDM demodulator of this invention shown in drawing 4 is explained.

[0040] Drawing 5 is an explanatory view explaining the wave of the OFDM rectangular cross carrier of No. even. The wave as which 70 express the rectangular carrier of the OFDM symbols Q98 and Q100, the wave as which 71 expresses the rectangular carrier of the QPSK symbols Q96 and Q102, the wave as which 72 expresses the rectangular carrier of the QPSK symbols Q94 and Q104, and 73 are the waves showing the rectangular carrier of the QPSK symbols Q0 and Q198 among drawing. An axis of abscissa is time amount, 1 time-slot time amount Ts expresses an OFDM symbol period, and an axis of ordinate is amplitude level.

[0041] the wave showing the rectangular carrier of the QPSK symbols Q98 and Q100 -- 70 is the wave of two periods in the OFDM symbol period of one time slot, and its a wave is the same to the core time of one time slot at the first half and the second half. the wave which expresses the rectangular carrier of the QPSK symbols Q96 and Q102 between synchronizations -- the wave which 71 is the wave of four periods and expresses the rectangular carrier of the OFDM symbols Q94 and Q104 -- the wave which 72 is the wave of six periods and expresses the rectangular carrier 73 of the QPSK symbols Q0 and Q198 -- 112 is the wave of 100 periods and its a wave is [all] the same at the first half and the second half.

[0042] Since the wave by which the QPSK modulation of each No. even rectangular cross carrier was carried out maintains predetermined relative topology relation mostly to a No. even rectangular cross carrier in one OFDM symbol period, a wave becomes the same in the first half and the second half like a No. even rectangular cross carrier. And the I signal which is complex data on the time-axis of a No. even rectangular cross carrier, and a Q signal are the real part and imaginary part of OFDM complex even number data which are the sum of the time amount axial-wave form where the QPSK modulation of two or more No. even rectangular cross carriers was carried out separately. Therefore, in an I signal and a Q signal, in one OFDM symbol period, a wave becomes the same in the first half and the second half similarly.

[0043] Drawing 6 is an explanatory view explaining the wave of the OFDM rectangular cross rectangular cross carrier of No. odd. The wave as which 74 express the rectangular carrier of the QPSK symbols Q99 and Q110, the wave as which 75 expresses the rectangular carrier of the QPSK symbols Q97 and Q103, the wave as which 76 expresses the rectangular carrier of the QPSK symbols Q95 and Q105, and 77 are the waves showing the rectangular carrier of the QPSK symbols Q1 and Q199 among drawing. An axis of abscissa expresses the OFDM symbol period which is time amount and is 1 time-slot time amount Ts, and an axis of ordinate is amplitude level.

[0044] the wave showing the rectangular carrier of the QPSK symbols Q99 and Q101 -- 74 is the wave of one period in the OFDM symbol period of one time slot, and a phase wave-like in the first half and the second half reverses it to the core time of one time slot. the wave which expresses the rectangular carrier of the QPSK symbols Q97 and Q103 between synchronizations -- the wave which 75 is the wave of three periods and expresses the rectangular carrier of the QPSK symbols Q95 and Q105 -- the wave which 76 is the wave of five periods and expresses the rectangular carrier of the QPSK symbols Q1 and Q199 -- 77 is the wave of 109 periods and a phase wave-like in the first half and the second half reverses all to the core time of one time slot.

[0045] Since predetermined relative topology relation is similarly maintained mostly to a No. odd rectangular cross carrier in one OFDM symbol period about the wave by which the QPSK modulation of each No. odd rectangular cross carrier was carried out, the phase wave-like in the first half and the second half is reversed like a No. odd rectangular cross carrier. And the I signal which is complex data on the time-axis of a No. odd rectangular cross carrier, and a Q signal are the real part and imaginary part of OFDM complex odd number data which are the wave-like sum on the time-axis by which the QPSK modulation of two or more No. odd rectangular cross carriers was carried out separately. Therefore, in one OFDM symbol period, the phase wave-like in the first half and the second half has reversed the I signal and the Q signal similarly.

[0046] The output of the serial/parallel-conversion section 50 is inputted into the wave processing section 60 for No. even rectangular cross carriers, and is made into the wave which eliminated the wave of the first half and interpolated the wave of the second half, and the same wave in the first half from the core of the complex data I and Q on the time-axis of the No. even rectangular cross carrier in an OFDM symbol by which the QPSK modulation was carried out. On the other hand, the output of the serial/parallel-conversion section 57 is inputted into the wave processing section 63 for

No. odd rectangular cross carriers, eliminates the wave of the first half from the core of the complex data I and Q on the time-axis of the No. odd rectangular cross carrier in an OFDM symbol by which the QPSK modulation was carried out, and is made into the wave which reversed the polarity and interpolated the wave of the second half, and the same wave in the first half.

[0047] The output of the wave processing section 63 for the wave processing section rectangular cross carriers for No. even rectangular cross carriers of No. 60 or odd is inputted into the FFT section 64 for the FFT section rectangular cross carriers for No. even rectangular cross carriers of No. 61 or odd, respectively, and serves as the OFDM even number symbol and OFDM odd number symbol which consist of inphase shaft (i) data on a frequency shaft, and orthogonal-axis (q) data like the conventional technique and which are the complex data aggregate. And it is inputted into the parallel series transducer 62, and these are the QPSK complex data streams Qk of the series-connected-type type of the same sequence as the time of transmission. It becomes and the original transmit data is restored in the reverse mapping section 65.

[0048] In addition, the function of the wave processing section 64 for the wave processing section rectangular cross carriers for No. even rectangular cross carriers of No. 60 or odd may be performed in the FFT section, respectively. That is, the wave in the first half of the complex data I and Q is eliminated, after repeating the wave of the second half and copying in the first half, the wave in the first half of the FFT processing section for No. even rectangular cross carriers changed into the complex data on a frequency shaft and the complex data I and Q is eliminated, and it is good also as the FFT processing section for No. odd rectangular cross carriers which changes the wave of the second half into the complex data on a frequency shaft after making it reversed and copying the polarity.

[0049] Thus, it becomes possible to recover only from the remaining periods excluding 50% of period from the head of one OFDM symbol period which is a period when the wave which delays and reaches from the effective symbol period preceded one symbol according to multi-pass active jamming is contained.

[0050]

[Effect of the Invention] While being able to raise frequency use effectiveness according to the OFDM modulator and OFDM demodulator of this invention since a guard interval is not inserted in a transmitting side while being able to reduce multi-pass active jamming so that clearly from the above explanation, since each rectangular carrier serves as perfect orthogonality relation, it can acquire the effectiveness that the each modulated interference between rectangular carriers decreases.

[Translation done.]

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TECHNICAL FIELD

[Industrial Application] This invention relates to the OFDM modulator and OFDM demodulator in the OFDM modulation technique which carries out digital modulation of two or more rectangular carriers by complex data.

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PRIOR ART

[Description of the Prior Art] The orthogonal frequency division multiplex method (it is called "OFDM" Orthogonal Frequency Division Multiplexing and the following.) which divides into two or more sequences the data which should be transmitted, and carries out digital modulation of two or more rectangular carriers according to each divided data sequence, respectively is learned. Since this modulation technique is rectangular frequency spectrum, its frequency use effectiveness is good, and since 1 symbol time amount is long, it is strong to multi-pass active jamming. Since it has such features, use to digital terrestrial broadcasting or digital mobile communications is considered.
[0003] Drawing 7 is an explanatory view explaining the conventional OFDM modulator. the inside of drawing, and 80 -- the mapping section and 81 -- the serial/parallel-conversion section and 82 -- the IFFT section and 83 -- for the LPF section, and 88 and 89, as for the oscillation section and 91, the multiplication section and 90 are [a D/A transducer, and 86 and 87 / a parallel series transducer, and 84 and 85 / the phase shift section and 92] adder units. As a digital modulation method for modulating each rectangular carrier, although it is easy to be the thing of arbitration, this conventional example shows the example using quadrature modulation methods generally adopted, such as QPSK and 16QAM. Theoretically, it can replace with a digital modulation method and an analog modulation method can also be used.
[0004] Transmit data is inputted into the mapping section 80, and the complex data which consist of inphase shaft (i) data which specify the amplitude to a rectangular carrier and relative topology for digital modulation, and orthogonal-axis (q) data are formed. This complex data is changed into a number equal to the number of the rectangular carriers which constitute OFDM of complex data aggregates (henceforth an "OFDM symbol") in the serial/parallel-conversion section 81. Each complex data which constitutes an OFDM symbol is assigned to two or more rectangular carriers according to an individual. This OFDM symbol is inputted into the IFFT section 82 which is the reverse fast-Fourier-transform section. The IFFT section 82 outputs the wave signal which digital modulation is carried out with the complex data with which each amplitude and phase of a rectangular carrier correspond, and is acquired. This wave signal is outputted in the form of the complex data on a time-axis in that case. The complex data on this time-axis express the wave (henceforth a "I signal") of the inphase component of a data point and the wave (henceforth a "Q signal") of an orthogonal component which digital modulation is carried out and are acquired. Although the complex data on the time-axis outputted from the IFFT section 82 are outputted to juxtaposition as data for every two or more:00 point on a time-axis, they are changed by the parallel series transducer 83 and serve as complex data on the time-axis of a series-connected-type type, an I signal, and a Q signal.
[0005] An I signal and a Q signal are changed into an analog signal by the D/A transducers 84 and 85, and are inputted into the multiplication sections 88 and 89 through the LPF sections 86 and 87 which are low pass filters, respectively. In the multiplication section 88, the multiplication of the sequence of an I signal should be carried out to the output of the oscillation section 90, and the phase shift should be multiplication-carried out by the sequence of a Q signal -90 degrees in the output of the oscillation section 90 by the phase shift section 91 in the multiplication section 89. Each output by which multiplication was carried out is added in an adder unit 92, and the sending signal by OFDM is outputted. In addition, the oscillation section 90 generates the carrier of the frequency f1 of a radio frequency band or an intermediate frequency band.
[0006] The case where digital modulation of the rectangular carrier is carried out for an example of actuation of the OFDM modulator shown in drawing 7 using QPSK is explained.
[0007] Drawing 8 is an explanatory view explaining symbol mapping of a QPSK modulation technique. For 43, as for the 2nd coordinate point of a symbol, and 45, the 1st coordinate point of a symbol and 44 are [the 3rd coordinate point of a symbol and 46] the 4th coordinate point of a symbol among drawing. The orthogonal axis of the phase to which the inphase shaft of the phase of a carrier and an inphase and an axis of abscissa cross at right angles, and the phase of a

carrier and an axis of ordinate cross at right angles is expressed. About the complex data at the time of using QPSK, it is the following and QPSK symbol Qk. It says. It sets in the mapping section 80 and is transmit data Sk. QPSK symbol Qk which corresponds and expresses the coordinate of four symbols on the unit circle of a radius 1 It is outputted. For example, it is divided into 2 bits at a time (Sk and Sk+1), and series-connected-type-type transmit data is Sk. QPSK symbol Qk It corresponds to the coordinate of an inphase shaft (i), and is Sk+1. QPSK symbol Qk It corresponds to the coordinate of an orthogonal axis (q). Consequently, QPSK symbol Qk which expresses the 1st coordinate point 43 of a symbol, the 2nd coordinate point 44, the 3rd coordinate point 45, and the 4th coordinate point 46 corresponding to transmit data (0 0), (0, 1), (1, 0), and (1, 1), respectively It is outputted. QPSK symbol Qk It is expressed with a degree type.
Qk = (1/root2) [(1-2Sk) + (1-2Sk+1)]
And serial QPSK symbol Qk = (Q0, Q1, and Q2, ..., Q199) of 200 is the parallel QPSK symbol of 200, Q0, Q1, and Q2, ..., Q199 by the serial/parallel-conversion section 81. It is changed and becomes one OFDM symbol.
[0008] Be [what is necessary / just although the block of the IFFT section 82 carries out reverse DFT, i.e., the reverse digital Fourier transform,], IFFT, i.e., a reverse fast Fourier transform, is usually used. When setting the number of rectangular carrier signals to 200, the reverse fast Fourier transform which makes a point size the value of 256 which serves as a exponentiation of 2 above this value is performed. In this example of explanation, the QPSK symbol Qk is assigned to 200 points among 256 points, the QPSK symbol corresponding to the 56 remaining points sets to 0, and the rectangular carrier corresponding to this is not transmitted. In addition, generally the QPSK symbol for a synchronization etc. is added.
[0009] Drawing 9 is an explanatory view explaining the arrangement on the frequency shaft of the conventional rectangular carrier. the inside of drawing, the rectangular carrier signal of plurality [104], and the QPSK symbol Qk corresponding to [105] each carrier signal in 107 corresponding to frequency spacing in center frequency and 106 it is . The axis of abscissa of a drawing expresses a frequency and an axis of ordinate expresses amplitude level. Ts is, transmitting spacing, i.e., the OFDM symbol period, of an OFDM symbol. The rectangular carrier signal 104 is arranged by 106 focusing on center frequency 105 at the right and left from the frequency spacing -100 of regular-intervals 1/Ts/Ts to 100/Ts. In this example, the number of the rectangular carrier signals 104 is 200, and, as for the QPSK symbol Qk 107 which is complex data, from Q0 to Q199 is assigned corresponding to each rectangular carrier signal 104. Frequency spectrum when digital modulation of each rectangular carrier is carried out by the QPSK symbol Qk 107 serves as the so-called sinx/x type of curve, and it is set to 0 in the frequency point of a contiguity rectangular cross carrier, and restores to the modulating signal of each rectangular carrier 104, without receiving interference mutually.
[0010] Drawing 10 is an explanatory view explaining the conventional guard interval. As for an effective symbol period and 110, the transmission wave form corresponding to one OFDM symbol Qk in 108 and 109 are [the posterior part of an effective symbol period and 111] guard intervals among drawing. Time Division Multiplexing of the same thing as about 20% of part 110 of the posterior part of the effective symbol period 109 of the transmission wave form corresponding to one OFDM symbol Qk is carried out so that it may be inserted in the guard interval 111 preceded with the effective symbol period 109 as a dummy signal. In addition, this Time Division Multiplexing is performed by the parallel series transducer 83 after processing by IFFT82. A guard interval is set up so that the signal which is overdue and comes according to the multi-pass active jamming in a transmission line at the time of reception may arrive at this guard band interval period 111, and a recovery performs about the effective symbol period 109 except this guard interval period 111 so that it may mention later.
[0011] Drawing 11 is an explanatory view explaining the conventional OFDM demodulator. the inside of drawing, and 120 -- the multiplication section and 121 -- the multiplication section and 122 -- the oscillation section and 123 -- the phase shift section and 124 -- the LPF section and 125 -- for the LPF section and 128, as for the FFT section and 130, the A/D-conversion section and 129 are [the A/D-conversion section and 126 / the serial/parallel-conversion section and 127 / a parallel series transducer and 131] the reverse mapping sections. The input signal of OFDM should be inputted into the multiplication section 120 and the multiplication section 121, multiplication should be carried out to the output of the oscillation section 122 in the multiplication section 120, and the phase shift should be multiplication-carried out -90 degrees in the output of the oscillation section by the phase shift section 123 in the multiplication section 121. The output of the multiplication section 120 is inputted into the serial/parallel-conversion section 126 as an I signal through the LPF section 124 and the A/D-conversion section 125 which are a low pass filter. The output of the multiplication section 121 is inputted into the serial/parallel-conversion section 126 as a Q signal through the LPF section 127 and the A/D-conversion section 128. The output of the serial/parallel-conversion section 126 is inputted into the FFT section 129, a fast Fourier transform is performed to it, it is inputted into the parallel series transducer 130,

serves as a serial signal, it is inputted into the reverse mapping section 131, and received data are obtained. Be [what is necessary / just although the block of the FFT section 129 carries out DFT, i.e., the digital Fourier transform,], FFT, i.e., a fast Fourier transform, is usually used.

[0012] An example of actuation of the conventional OFDM demodulator shown in drawing 11 is explained about the case where digital modulation of the rectangular carrier is carried out by QPSK. A recovery serves as a reverse process at the time of a modulation mostly. In the multiplication sections 120 and 121, on a frequency f1, a rectangular recovery is carried out and an input signal is divided into the complex signal on the time-axis of a series-connected-type type. These become the complex data, I signal, and Q signal on a time-axis through the LPF sections 124 and 127 and the A/D-conversion sections 125 and 128. This I signal and Q signal are parallelized in the serial/parallel-conversion section 126, in the FFT processing section 129, FFT processing of 256 points is performed, and they are changed into the complex data on a frequency shaft, and serve as an OFDM symbol. This OFDM symbol is the QPSK symbol Qk which is complex data which consist of inphase shaft (i) data and orthogonal-axis (q) data. It is gathering. In that case, the part of the guard interval 111 in an OFDM symbol is disregarded, and FFT processing of the 256 remaining points is carried out. The complex data Q0 which constitute an OFDM symbol, and Q1, ..., Q199 It is changed into complex series-connected-type-type data in the parallel series transducer 130, and the same received data as the original transmit data are obtained in the reverse mapping section 131.

[0013] However, since time base compaction of the effective OFDM symbol period 109 will be carried out as a result of inserting the guard interval 111, breadth and the use effectiveness of a frequency fall [rectangular carrier spacing on a frequency shaft]. Moreover, since the orthogonality of each carrier on a frequency shaft will collapse, the rectangular carrier by which digital modulation was carried out will receive interference mutually.

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EFFECT OF THE INVENTION

[Effect of the Invention] While being able to raise frequency use effectiveness according to the OFDM modulator and OFDM demodulator of this invention since a guard interval is not inserted in a transmitting side while being able to reduce multi-pass active jamming so that clearly from the above explanation, since each rectangular carrier serves as perfect orthogonality relation, it can acquire the effectiveness that the each modulated interference between rectangular carriers decreases.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] This invention was made in view of the situation mentioned above, and aims at offering the modulator and demodulator which can reduce multi-pass active jamming, without inserting a guard interval between effective symbol periods in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence.

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MEANS

[Means for Solving the Problem] This invention is set to invention according to claim 1. In the OFDM modulator in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence The serial/parallel-conversion means which distributes a complex data sequence to two sequences, and assigns this each sequence to the even-numbered rectangular carrier and the odd-numbered rectangular carrier, The sequence assigned to the even-numbered rectangular carrier by this serial/parallel-conversion means, And the reverse DFT processing section for No. even carriers and the reverse DFT processing section for No. odd carriers which perform reverse DFT processing, respectively and output the complex data wave on a time-axis to the sequence assigned to the odd-numbered rectangular carrier, It is characterized by having two quadrature modulation machines which carry out quadrature modulation with the output of each of said reverse DFT processing section.
[0016] In the OFDM demodulator in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence in invention according to claim 2 Two rectangular demodulators for carrying out the rectangular recovery of the rectangular recovery signal of a No. even carrier, and the rectangular recovery signal of a No. odd carrier, respectively, The wave processing section for No. even carriers which eliminates the wave of the first half for the complex data on the time-axis of the No. even carrier which is obtained by one side of this rectangular demodulator, and by which digital modulation was carried out from the core of an OFDM symbol, and interpolates the wave of the second half, and the same wave in the first half, The FFT processing section for No. even carriers which changes the output of this wave processing section for No. even carriers into the complex data on a frequency shaft, The wave processing section for No. odd carriers which eliminates the wave of the first half for the complex data on the time-axis of the No. odd carrier which is obtained by another side of said rectangular demodulator, and by which digital modulation was carried out from the core of an OFDM symbol, reverses the polarity and interpolates the wave of the second half, and the same wave in the first half, The FFT processing section for No. odd carriers which changes the output of this wave processing section for No. odd carriers into the complex data on a frequency shaft, It is characterized by having a parallel-serial conversion means to change into the complex data sequence on a series-connected-type-type frequency shaft the complex data sequence on two parallel frequency shafts acquired from said two FFT processing sections.
[0017] In the OFDM modulator in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence in invention according to claim 3 The serial/parallel-conversion means which distributes a complex data sequence to two sequences, and assigns this each sequence to the even-numbered rectangular carrier and the odd-numbered rectangular carrier, The sequence assigned to the even-numbered rectangular carrier by this serial/parallel-conversion means, And the reverse DFT processing section for No. even carriers and the reverse DFT processing section for No. odd carriers which perform reverse DFT processing, respectively and output the complex data wave on a time-axis to the sequence assigned to the odd-numbered rectangular carrier, the two 1st quadrature modulation machines which carry out quadrature modulation of the carrier of the 1st frequency with the output of each of said reverse DFT processing section -- this -- it is characterized by having the 2nd quadrature modulation machine which carries out quadrature modulation of the carrier of the 2nd frequency with each output of the two 1st quadrature modulation machines.
[0018] In the OFDM demodulator in the OFDM modulation technique to which digital modulation of two or more rectangular carriers was carried out by the complex data sequence in invention according to claim 4 The 2nd rectangular demodulator for carrying out the rectangular recovery of the input signal on the carrier of the 2nd frequency, this -- the rectangular recovery signal of a No. even carrier and the rectangular recovery signal of a No. odd carrier which are acquired by the 2nd rectangular demodulator on the carrier of the 1st frequency with the 1st two rectangular demodulator which carries out a rectangular recovery, respectively this -- with the wave processing section

for No. even carriers which eliminates the wave of the first half for the complex data on the time-axis of the No. even carrier which is obtained by one side of the 1st rectangular demodulator, and by which digital modulation was carried out from the core of an OFDM symbol, and interpolates the wave of the second half, and the same wave in the first half The FFT processing section for No. even carriers which changes the output of this wave processing section for No. even carriers into the complex data on a frequency shaft, The wave processing section for No. odd carriers which eliminates the wave of the first half for the complex data on the time-axis of the No. odd carrier which is obtained by another side of said 2nd rectangular demodulator, and by which digital modulation was carried out from the core of an OFDM symbol, reverses the polarity and interpolates the wave of the second half, and the same wave in the first half, The FFT processing section for No. odd carriers which changes the output of this wave processing section for No. odd carriers into the complex data on a frequency shaft, It is characterized by having a parallel-serial conversion means to change into the complex data sequence on a series-connected-type-type frequency shaft the complex data sequence on two parallel frequency shafts acquired from said two FFT processing sections.

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OPERATION

[Function] In an OFDM modulator, the even-numbered modulated rectangular carrier and the odd-numbered modulated rectangular carrier are transmitted independently. In an OFDM demodulator, 50% of period is not used for a recovery from the head of an OFDM symbol where the wave which delays and reaches from the effective symbol period preceded according to multi-pass active jamming is contained. About the even-numbered modulated rectangular carrier, the even-numbered modulated rectangular carrier and the odd-numbered modulated rectangular carrier interpolate the same thing as 50% of the second half in the first half, and recovers from having the symmetric property of a proper in 1 symbol, respectively. About the odd-numbered modulated carrier, it is made reversed, and the same thing as 50% of the second half is interpolated in the first half, and is restored to a polarity. Since a guard interval is not inserted in a transmitting side while being able to reduce multi-pass active jamming, since the period of the first half which has received multi-pass active jamming is not used for a recovery, while being able to raise frequency use effectiveness, since each carrier serves as perfect orthogonality relation, its each modulated interference between rectangular carriers decreases.

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EXAMPLE

[Example] Drawing 1 is an explanatory view explaining one example of the OFDM modulator of this invention. One among drawing the serial/parallel-conversion section and 3 for the mapping section and 2 The IFFT section for No. even carriers, 4 a parallel series transducer, and 7 and 8 for the IFFT section for No. odd carriers, and 5 and 6 A D/A transducer, As for the LPF section, and 11 and 12, 9 and 10 the 1st oscillation section and 14 for the multiplication section and 13 The 1st phase shift section, 15 -- an adder unit, and 16 and 17 -- a D/A transducer, and 18 and 19 -- for an adder unit, and 23 and 24, as for the 2nd oscillation section and 26, the multiplication section and 25 are [the LPF section, and 20 and 21 / the multiplication section and 22 / the 2nd phase shift section and 27] adder units. As a digital modulation method for modulating each rectangular carrier, although it is easy to be the thing of arbitration, this example shows the example which uses quadrature modulation methods, such as QPSK and 16QAM. Theoretically, it can replace with a digital modulation method and an analog modulation method can also be used.
[0021] Transmit data is inputted into the mapping section 1, it is mapped and complex data are formed. This complex data is changed into an OFDM symbol in the serial/parallel-conversion section 2. However, unlike the conventional technique, complex data are divided and distributed to two, an OFDM even number symbol and an OFDM odd number symbol. An OFDM even number symbol is assigned to each of a No. even rectangular cross carrier, and an OFDM odd number symbol is assigned to each of a No. odd rectangular cross carrier. Since the total of a rectangular carrier is generally made [more] than the total of the complex data which constitute an OFDM symbol, complex 0 is assigned to the rectangular remaining carriers to which complex data are not assigned. An OFDM even number symbol is inputted into the IFFT section 3 for No. even carriers, an OFDM odd number symbol is inputted into the IFFT section 4 for No. odd carriers, the reverse fast Fourier transform of the complex assigned to each carrier is carried out per OFDM symbol, respectively, and it is changed into the complex data on a time-axis. The output of the IFFT section 3 for No. even carriers is inputted into the parallel series transducer 5, and serves as the I signal and Q signal which are complex data on the time-axis of a series-connected-type type. Similarly, the output of the IFFT section 4 for No. odd carriers is inputted into the parallel series transducer 6, and serves as the I signal and Q signal which are two or more data on the time-axis of a series-connected-type type. The I signal and Q signal which are the output of the parallel series transducer 5 are changed into an analog wave by the D/A transducers 7 and 8, respectively, and are inputted into the multiplication sections 11 and 12 through the LPF sections 9 and 10 which are low pass filters. In the multiplication section 11, the multiplication of the sequence of an I signal should be carried out to the output of the 1st oscillation section 13 of a frequency f1, and the phase shift should be multiplication-carried out by the sequence of a Q signal -90 degrees in the output of the 1st oscillation section 13 by the 1st phase shift section 14 in the multiplication section 12. Each output by which multiplication was carried out is added in an adder unit 15, and serves as I' signal.
[0022] Similarly, the I signal and Q signal which are the output of the parallel series transducer 6 are changed into an analog wave by the D/A transducers 16 and 17, respectively, and are inputted into the multiplication sections 20 and 21 through a low pass filter 18 and LPF 19. In the multiplication section 20, the multiplication of the sequence of an I signal should be carried out to the output of the 1st oscillation section 13 of a frequency f1, and the phase shift should be multiplication-carried out by the sequence of a Q signal -90 degrees in the output of the 1st oscillation section 13 by the 1st phase shift section 14 in the multiplication section 21. Each output by which multiplication was carried out is added in an adder unit 22, and serves as Q' signal. I' signal was inputted into the multiplication section 23, multiplication should be carried out to the output of the 2nd oscillation section 25 of a frequency f2, Q' signal should be inputted into the multiplication section 24, and the phase shift should be multiplication-carried out -90 degrees in the output of the 2nd oscillation section 25 of a frequency f2 by the 2nd phase shift section 26. The output of the multiplication section 23 and the output of the multiplication section 24 are added in an adder unit 27, and serve as a sending signal. In addition, a guard interval is not inserted in the OFDM modulator of this invention.

[0023] The case where digital modulation of the rectangular carrier is carried out for an example of actuation of the OFDM modulator shown in drawing 1 using QPSK is explained. About symbol mapping, it is the same as that of the case of the conventional technique explained by drawing 8 . transmit data is inputted into the mapping section 1, and changes into serial QPSK symbol Qk = (Q0, Q1, and Q2, ..., Q199) of 200 -- having -- the serial/parallel-conversion section 2 -- the parallel QPSK symbol of 200, Q0, Q1, and Q2 ... and Q199 from -- it is changed into one becoming OFDM symbol. Under the present circumstances, one OFDM symbol is divided into two sets. Here, it is kicked by two, the OFDM even number symbol which consists of even-numbered QPSK symbol QkE= (Q0, Q2, and Q4, ..., Q198), and the OFDM odd number symbol which consists of odd-numbered QPSK symbol QkO= (Q1, Q3, and Q5, ..., Q199), by the group. Furthermore, an OFDM even number symbol is assigned to the even-numbered carrier (the lowest frequency 1/the even times as many carrier as Ts except DC) of the carrier of 200 which transmits, and an OFDM odd number symbol is assigned to it by the odd-numbered carrier (the lowest frequency 1/the odd times as many carrier as Ts except DC).

[0024] Drawing 2 is an explanatory view explaining arrangement of the rectangular carrier to which an OFDM even number symbol is assigned. the inside of drawing, the carrier signal of plurality [30], and the QPSK symbol Qk corresponding to [31] each carrier signal in 33 corresponding to frequency spacing in center frequency and 32 it is . The axis of abscissa of a drawing expresses a frequency and an axis of ordinate expresses amplitude level. Ts is, transmitting spacing, i.e., the OFDM symbol period, of an OFDM symbol. The rectangular carrier signal 30 is arranged by 32 focusing on center frequency 31 at the right and left from the frequency spacing -100 of regular-intervals 2/Ts/Ts to 100/Ts. In this example, the number of the rectangular carrier signals 30 is 100, and, as for the QPSK symbol Qk 33, from Q0 to Q198 is assigned corresponding to each carrier signal 30. Each rectangular carrier is the QPSK symbol Qk like the conventional technique. Frequency spectrum when digital modulation is carried out and digital modulation of each rectangular carrier is carried out serves as the so-called sinx/x type of curve, and is set to 0 in a midpoint with the frequency point of a contiguity carrier, and the frequency point of a contiguity carrier.

[0025] Drawing 3 is an explanatory view explaining arrangement of the rectangular carrier to which an OFDM odd number symbol is assigned. the inside of drawing, the carrier signal of plurality [34], and the QPSK symbol Qk corresponding to [35] each carrier signal in 37 corresponding to frequency spacing in center frequency and 36 it is . The axis of abscissa of a drawing expresses a frequency shaft, and an axis of ordinate expresses amplitude level. Ts is, transmitting spacing, i.e., the OFDM symbol period, of an OFDM symbol. The carrier signal 70 is arranged from **1/Ts by 36 focusing on center frequency 35 at the right and left from spacing 2/the frequency spacing -99 of Ts/Ts to 99/Ts. In this example, the number of the carrier signals 34 is 100, and, as for the QPSK symbol Qk 37, from Q1 to Q199 is assigned corresponding to each carrier signal 34. Frequency spectrum when digital modulation of each rectangular carrier is carried out with complex data like the conventional technique and digital modulation of each rectangular carrier is carried out serves as the so-called sinx/x type of curve, and is set to 0 in a midpoint with the frequency point of a contiguity carrier, and the frequency point of a contiguity carrier.

[0026] Be [what is necessary / just although the block of the IFFT section 3 for No. even carriers carries out reverse DFT, i.e. the reverse digital Fourier transform,], in this one example, IFFT, i.e., a reverse fast Fourier transform, is used. When setting the total of a rectangular carrier signal to 200, the reverse fast Fourier transform which makes a point size the value of 256 which serves as a exponentiation of 2 above this value is performed. In this one example, an OFDM even number symbol is assigned to 100 points among 256 points, the QPSK symbol corresponding to the remaining point sets to 0, and the rectangular carrier corresponding to this is not transmitted. In addition, the even-numbered QPSK symbol for a synchronization etc. may be added, and the QPSK modulation of the rectangular carrier which corresponds by this may be carried out.

[0027] In IFFT3 for No. even carriers, reverse fast-Fourier-transform processing is carried out by 256 points, and an OFDM even number symbol is changed into the complex data of 256 points in a time-axis, is arranged in on a time-axis by the parallel series transducer 5, and is outputted by the series-connected-type formula. That is, the sum (henceforth "OFDM complex even number data") on the time-axis of the No. even rectangular cross carrier in which the QPSK modulation was carried out by the OFDM even number symbol is outputted according to the I signal of real part, and the Q signal of imaginary part. For example, wave x(t) on the time-axis of QPSK symbol QkE= (Q0, Q2, and Q4, ..., Q198) which constitutes an OFDM even number symbol is expressed with a degree type.

xE (t) =sigmak=-100 100 Qk+100 and exp (j2pikt/Ts)

However, k is -100, -98, -4, -2, and 2, 4, ..., 98,100.

[0028] In the modulator which consists of the multiplication sections 11 and 12 and an adder unit 15, quadrature modulation of each sequence of the I signal of OFDM complex even number data and a Q signal is carried out by the carrier of a frequency f1.

[0029] Be [what is necessary / just although reverse DFT is similarly carried out about the block of the IFFT section 4 for No. odd carriers], in this one example, IFFT is used and the reverse fast Fourier transform of POIN is performed in 256. In this one example, an OFDM even number symbol is assigned to 100 points among 256 points, the QPSK symbol corresponding to the remaining point sets to 0, and the rectangular carrier corresponding to this is not transmitted. In addition, the odd-numbered QPSK symbol for a synchronization etc. may be added, and the QPSK modulation of the rectangular carrier which corresponds by this may be carried out.

[0030] In IFFT4 for No. odd carriers, reverse fast-Fourier-transform processing is carried out by 256 points, and an OFDM odd number symbol is changed into the complex data of 256 points in a time-axis, is arranged in on a time-axis by the parallel series transducer 6, and is outputted by the series-connected-type formula. That is, the sum (henceforth "OFDM complex odd number data") on the time-axis of the No. odd rectangular cross carrier in which the QPSK modulation was carried out by the OFDM odd number symbol is generated according to the I signal of real part, and the Q signal of imaginary part. For example, wave x(t) on the time-axis of QPSK symbol QkO= (Q1, Q3, and Q5, ..., Q199) which constitutes an OFDM odd number symbol is expressed with a degree type.

xO (t) =sigmak=-99 99 Qk+100 and exp (j2pikt/Ts)

However, k is -99, -97, .., -3, -1, 1 and 3, .., 97 and 99.

[0031] In the modulator which consists of the multiplication sections 20 and 21 and an adder unit 22, quadrature modulation of each sequence of the I signal of OFDM complex odd number data and a Q signal is carried out by the carrier of a frequency f1. In the modulator which consists of the multiplication sections 23 and 24 and an adder unit 27, quadrature modulation of the I'signal and Q' signal is further carried out on the carrier of a frequency f2.

[0032] In the above one example, the 2nd step of quadrature modulation is given in the modulator with which I'signal and Q' signal consists of the multiplication sections 23 and 24 and an adder unit 27. However, since a recovery which will mention I'signal and Q' signal later in a receiving side if it transmits independently is attained, the 2nd step of this quadrature modulation is only one example for transmitting independently. Since the approach of transmitting two signals independently has various methods as a multiplex transmission system, the multiplex transmission system of arbitration can be used for it, and it can transmit I'signal and Q' signal independently. Since the guard interval is not inserted, each carrier serves as perfect orthogonality relation.

[0033] In addition, although the analog circuit was used for each modulator, it may be realized by digital signal processing. For example, when digital signal processing realizes all modulators, the D/A transducers 7, 8, 16, and 17 are omitted, D/A conversion is carried out to the last of digital signal processing, and a sending signal is outputted.

[0034] Drawing 4 is an explanatory view explaining one example of the OFDM demodulator of this invention. 40 and 41 among drawing the 2nd oscillation section and 43 for the multiplication section and 42 The 2nd phase shift section, In 44 and 45, the multiplication section and 46 the 1st phase shift section and 48 for the 1st oscillation section and 47 The LPF section, In 49, the A/D-conversion section and 50 the LPF section and 52 for the serial/parallel-conversion section and 51 The A/D-conversion section, In 53 and 54, the multiplication section and 55 the A/D-conversion section and 57 for the LPF section and 56 The serial/parallel-conversion section, 58 -- the LPF section and 59 -- for the FFT section for No. even carriers, and 62, as for the wave processing section for No. odd carriers, and 64, a parallel series transducer and 63 are [the A/D-conversion section and 60 / the wave processing section for No. even carriers, and 61 / the FFT section for No. odd carriers and 65] the reverse mapping sections.

[0035] An input signal is inputted into the multiplication section 40 and the multiplication section 41, and multiplication is carried out to the output of the 2nd oscillation section 42 of a frequency f2 in the multiplication section 40, it turns into I' signal, and the output of the 2nd oscillation section 42 serves as [that the phase shift should be multiplication-carried out -90 degrees and] Q' signal by the 2nd phase shift section 43 in the multiplication section 41. This I'signal and Q' signal is equivalent to I'signal and Q' signal in the OFDM modulator explained by drawing 1 . I' signal should be inputted into the multiplication section 44 and the multiplication section 45, multiplication should be carried out to the output of the 1st oscillation section 46 of a frequency f1 in the multiplication section 44, and the phase shift should be multiplication-carried out -90 degrees in the output of the 1st oscillation section 46 by the 1st phase shift section 47 in the multiplication section 45. The output of the multiplication section 44 serves as an I signal which is a digital signal through the LPF section 48 and the A/D-conversion section 49 which are a low pass filter, and is inputted into the serial/parallel-conversion section 50. The output of the multiplication section 45 serves as a Q signal which is a digital signal through the LPF section 51 and the A/D-conversion section 52 which are a low pass filter, and is inputted into the serial/parallel-conversion section 50. This I signal and Q signal correspond to the real part and imaginary part of the OFDM complex even number data explained by drawing 1 , and are changed into the complex parallel-connected-type-type data in the time-axis of 256 points in the serial/parallel-conversion section 50.

[0036] On the other hand, Q' signal which is the output of the multiplication section 41 should be inputted into the multiplication sections 53 and 54, multiplication should be carried out to the output of the 1st oscillation section 46 of a frequency f1 in the multiplication section 53, and the phase shift should be multiplication-carried out -90 degrees in the output of the 1st oscillation section 46 by the 1st phase shift section 47 in the multiplication section 54. The output of the multiplication section 53 serves as an I signal which is an analog signal through the LPF section 55 and the A/D-conversion section 56 which are a low pass filter, and is inputted into the serial/parallel-conversion section 57. The output of the multiplication section 54 serves as a Q signal which is an analog signal through the LPF section 58 and the A/D-conversion section 59 which are a low pass filter, and is inputted into the serial/parallel-conversion section 57. This I signal and Q signal correspond to the real part and imaginary part of the OFDM complex odd number data explained by drawing 1 . It is changed into the complex parallel-connected-type-type data in the time-axis of 256 points in the serial/parallel-conversion section 57.

[0037] The complex parallel-connected-type-type data in the time-axis of 256 points which are the output of the serial/parallel-conversion section 50 It is inputted into the wave processing section 60 for No. even carriers, the wave processing mentioned later is made, and it sets in the FFT processing section 60 for No. even carriers after ****. FFT processing of 256 points is performed, and it is changed into the complex data on a frequency shaft, and becomes the OFDM even number symbol which is the complex data aggregate which consists of inphase shaft (i) data and orthogonal-axis (q) data. The complex data Q0 changed on the frequency shaft, and Q2, ..., Q198 It is inputted into the parallel series transducer 62. On the other hand, the complex parallel-connected-type-type data in the time-axis of 256 points which are the output of the serial/parallel-conversion section 57 In the FFT processing section 64 for the No. odd carriers after the wave processing which it is inputted into the wave processing section 63 for No. odd carriers, and is mentioned later was made FFT processing of 256 points is performed, and it is changed into the complex data on a frequency shaft, and becomes the OFDM odd number symbol which is the complex data aggregate which consists of inphase shaft (i) data and orthogonal-axis (q) data. The complex data Q1 changed on the frequency shaft, and Q3, ..., Q199 It is inputted into the parallel series transducer 62.

[0038] Complex series-connected-type-type data Qk which an OFDM even number symbol and an OFDM odd number symbol are unified in the parallel series transducer 62, and constitutes an OFDM symbol It is changed and the same received data as the original transmit data are obtained in the mapping section 131.

[0039] The case where digital modulation of the rectangular carrier is carried out by QPSK in an example of actuation of the OFDM demodulator of this invention shown in drawing 4 is explained.

[0040] Drawing 5 is an explanatory view explaining the wave of the OFDM rectangular cross carrier of No. even. The wave as which 70 express the rectangular carrier of the OFDM symbols Q98 and Q100, the wave as which 71 expresses the rectangular carrier of the QPSK symbols Q96 and Q102, the wave as which 72 expresses the rectangular carrier of the QPSK symbols Q94 and Q104, and 73 are the waves showing the rectangular carrier of the QPSK symbols Q0 and Q198 among drawing. An axis of abscissa is time amount, 1 time-slot time amount Ts expresses an OFDM symbol period, and an axis of ordinate is amplitude level.

[0041] the wave showing the rectangular carrier of the QPSK symbols Q98 and Q100 -- 70 is the wave of two periods in the OFDM symbol period of one time slot, and its a wave is the same to the core time of one time slot at the first half and the second half. the wave which expresses the rectangular carrier of the QPSK symbols Q96 and Q102 between synchronizations -- the wave which 71 is the wave of four periods and expresses the rectangular carrier of the OFDM symbols Q94 and Q104 -- the wave which 72 is the wave of six periods and expresses the rectangular carrier 73 of the QPSK symbols Q0 and Q198 -- 112 is the wave of 100 periods and its a wave is [all] the same at the first half and the second half.

[0042] Since the wave by which the QPSK modulation of each No. even rectangular cross carrier was carried out maintains predetermined relative topology relation mostly to a No. even rectangular cross carrier in one OFDM symbol period, a wave becomes the same in the first half and the second half like a No. even rectangular cross carrier. And the I signal which is complex data on the time-axis of a No. even rectangular cross carrier, and a Q signal are the real part and imaginary part of OFDM complex even number data which are the sum of the time amount axial-wave form where the QPSK modulation of two or more No. even rectangular cross carriers was carried out separately. Therefore, in an I signal and a Q signal, in one OFDM symbol period, a wave becomes the same in the first half and the second half similarly.

[0043] Drawing 6 is an explanatory view explaining the wave of the OFDM rectangular cross rectangular cross carrier of No. odd. The wave as which 74 express the rectangular carrier of the QPSK symbols Q99 and Q110, the wave as which 75 expresses the rectangular carrier of the QPSK symbols Q97 and Q103, the wave as which 76 expresses the rectangular carrier of the QPSK symbols Q95 and Q105, and 77 are the waves showing the rectangular carrier of the QPSK symbols Q1 and Q199 among drawing. An axis of abscissa expresses the OFDM symbol period which is time amount and is 1 time-slot time amount Ts, and an axis of ordinate is amplitude level.

[0044] the wave showing the rectangular carrier of the QPSK symbols Q99 and Q101 -- 74 is the wave of one period in the OFDM symbol period of one time slot, and a phase wave-like in the first half and the second half reverses it to the core time of one time slot. the wave which expresses the rectangular carrier of the QPSK symbols Q97 and Q103 between synchronizations -- the wave which 75 is the wave of three periods and expresses the rectangular carrier of the QPSK symbols Q95 and Q105 -- the wave which 76 is the wave of five periods and expresses the rectangular carrier of the QPSK symbols Q1 and Q199 -- 77 is the wave of 109 periods and a phase wave-like in the first half and the second half reverses all to the core time of one time slot.

[0045] Since predetermined relative topology relation is similarly maintained mostly to a No. odd rectangular cross carrier in one OFDM symbol period about the wave by which the QPSK modulation of each No. odd rectangular cross carrier was carried out, the phase wave-like in the first half and the second half is reversed like a No. odd rectangular cross carrier. And the I signal which is complex data on the time-axis of a No. odd rectangular cross carrier, and a Q signal are the real part and imaginary part of OFDM complex odd number data which are the wave-like sum on the time-axis by which the QPSK modulation of two or more No. odd rectangular cross carriers was carried out separately. Therefore, in one OFDM symbol period, the phase wave-like in the first half and the second half has reversed the I signal and the Q signal similarly.

[0046] The output of the serial/parallel-conversion section 50 is inputted into the wave processing section 60 for No. even rectangular cross carriers, and is made into the wave which eliminated the wave of the first half and interpolated the wave of the second half, and the same wave in the first half from the core of the complex data I and Q on the time-axis of the No. even rectangular cross carrier in an OFDM symbol by which the QPSK modulation was carried out. On the other hand, the output of the serial/parallel-conversion section 57 is inputted into the wave processing section 63 for No. odd rectangular cross carriers, eliminates the wave of the first half from the core of the complex data I and Q on the time-axis of the No. odd rectangular cross carrier in an OFDM symbol by which the QPSK modulation was carried out, and is made into the wave which reversed the polarity and interpolated the wave of the second half, and the same wave in the first half.

[0047] The output of the wave processing section 63 for the wave processing section rectangular cross carriers for No. even rectangular cross carriers of No. 60 or odd is inputted into the FFT section 64 for the FFT section rectangular cross carriers for No. even rectangular cross carriers of No. 61 or odd, respectively, and serves as the OFDM even number symbol and OFDM odd number symbol which consist of inphase shaft (i) data on a frequency shaft, and orthogonal-axis (q) data like the conventional technique and which are the complex data aggregate. And it is inputted into the parallel series transducer 62, and these are the QPSK complex data streams Qk of the series-connected-type type of the same sequence as the time of transmission. It becomes and the original transmit data is restored in the reverse mapping section 65.

[0048] In addition, the function of the wave processing section 64 for the wave processing section rectangular cross carriers for No. even rectangular cross carriers of No. 60 or odd may be performed in the FFT section, respectively. That is, the wave in the first half of the complex data I and Q is eliminated, after repeating the wave of the second half and copying in the first half, the wave in the first half of the FFT processing section for No. even rectangular cross carriers changed into the complex data on a frequency shaft and the complex data I and Q is eliminated, and it is good also as the FFT processing section for No. odd rectangular cross carriers which changes the wave of the second half into the complex data on a frequency shaft after making it reversed and copying the polarity.

[0049] Thus, it becomes possible to recover only from the remaining periods excluding 50% of period from the head of one OFDM symbol period which is a period when the wave which delays and reaches from the effective symbol period preceded one symbol according to multi-pass active jamming is contained.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is an explanatory view explaining one example of the OFDM modulator of this invention.
[Drawing 2] It is an explanatory view explaining arrangement of the rectangular carrier to which an OFDM even number symbol is assigned.
[Drawing 3] It is an explanatory view explaining the arrangement on the frequency shaft of the rectangular carrier to which an OFDM odd number symbol is assigned.
[Drawing 4] It is an explanatory view explaining one example of the OFDM demodulator of this invention.
[Drawing 5] It is an explanatory view explaining the wave of the OFDM rectangular cross carrier of No. even.
[Drawing 6] It is an explanatory view explaining the wave of the OFDM rectangular cross carrier of No. odd.
[Drawing 7] It is an explanatory view explaining the conventional OFDM modulator.
[Drawing 8] It is an explanatory view explaining symbol mapping of a QPSK modulation technique.
[Drawing 9] It is an explanatory view explaining the arrangement on the frequency shaft of the conventional rectangular carrier.
[Drawing 10] It is an explanatory view explaining the conventional guard interval.
[Drawing 11] It is an explanatory view explaining the conventional OFDM demodulator.
[Description of Notations]
1 -- The mapping section, 2 -- The serial/parallel-conversion section, the IFFT section for No. 3--even carriers, 5 The IFFT section for No. 4--odd carriers, 6 -- A parallel series transducer, 13 -- The 1st oscillation section, 14 [-- The 2nd oscillation section,] -- The 1st phase shift section, 25 -- The 2nd oscillation section, 26 -- The 2nd phase shift section, 42 43 [-- The serial/parallel-conversion section, the FFT section for No. 61--even carriers 62 / -- A parallel series transducer, the wave processing section for No. 63--odd carriers, the FFT section for No. 64--odd carriers, 65 / -- Reverse mapping section.] -- The 2nd phase shift section, 46 -- The 1st oscillation section, 47 -- 50 The 1st phase shift section, 57

[Translation done.]

* NOTICES *

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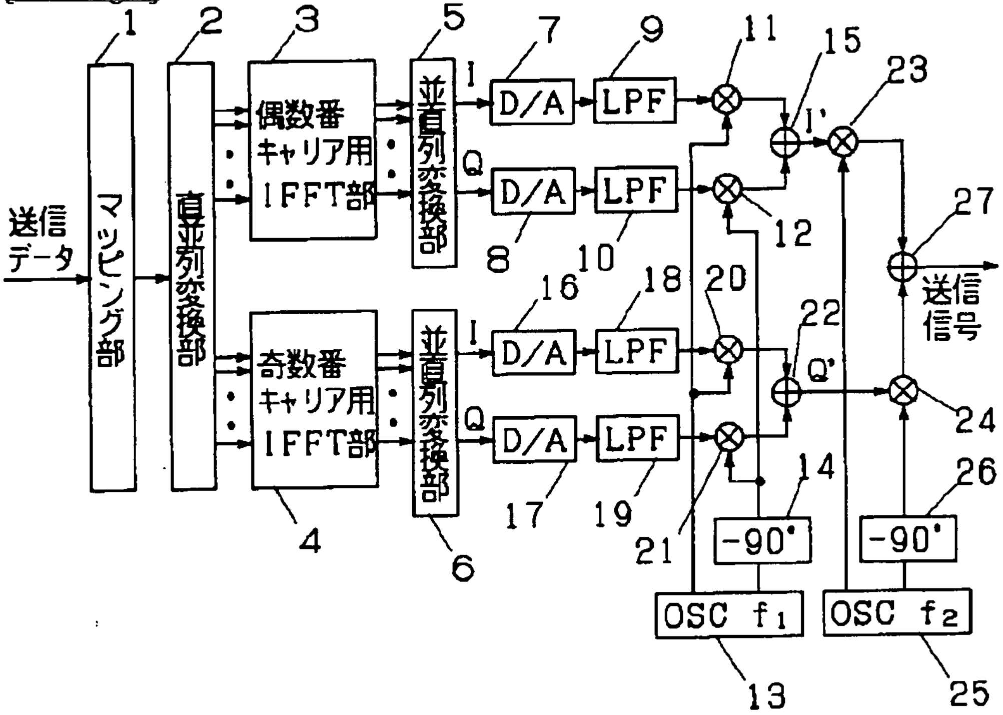
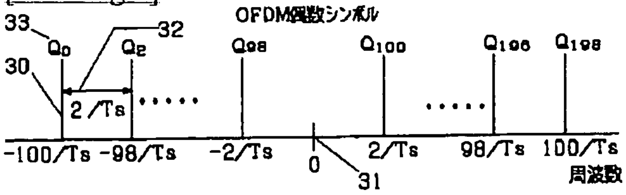
DRAWINGS

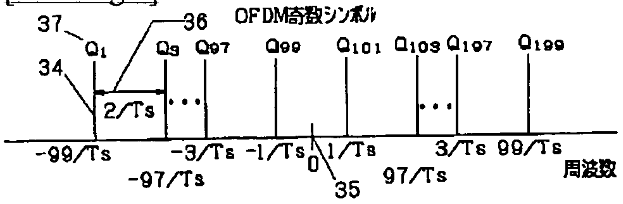
[Drawing 1]


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
送信データ
マッピング部
直並列変換部
偶数番キャリア用IFFT部
奇数番キャリア用IFFT部
並直列変換部
並直列変換部
I
Q
I
Q
D/A
D/A
D/A
D/A
LPF
LPF
LPF
LPF
I'
Q'
-90°
-90°
OSC f1
OSC f2
送信信号

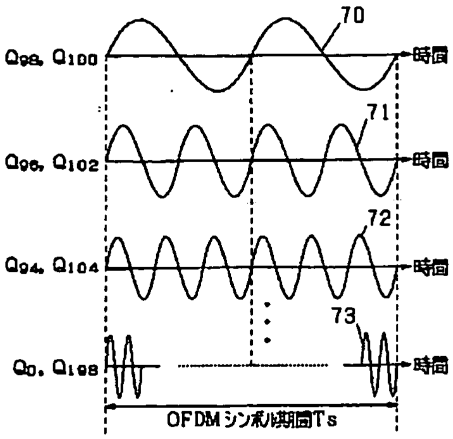
[Drawing 2]


OFDM偶数シンボル
33
32
30
31
Q0
Q2
Q98
Q100
Q196
Q198
2/Ts
-100/Ts
-98/Ts
-2/Ts
0
2/Ts
98/Ts
100/Ts
周波数

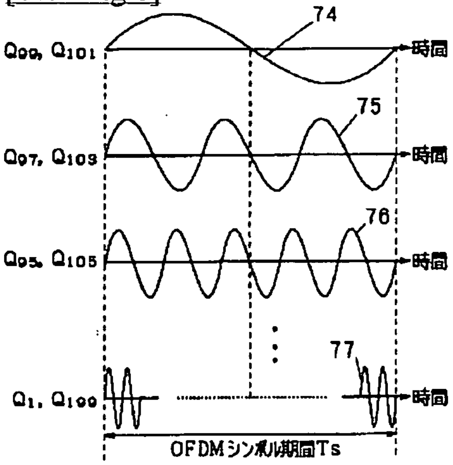
[Drawing 3]


OFDM奇数シンボル
37
36
34
35
Q1
Q3
Q97
Q99
Q101
Q103
Q197
Q199
2/Ts
-99/Ts
-97/Ts
-3/Ts
-1/Ts
0
1/Ts
3/Ts
97/Ts
99/Ts
周波数

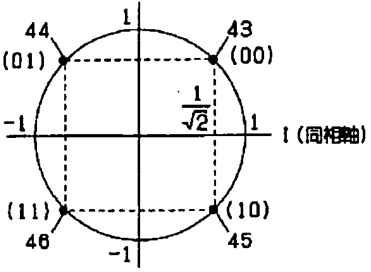
[Drawing 5]


Q98, Q100
70
時間
Q96, Q102
71
時間
Q94, Q104
72
時間
73
Q0, Q198
時間
OFDMシンボル期間Ts

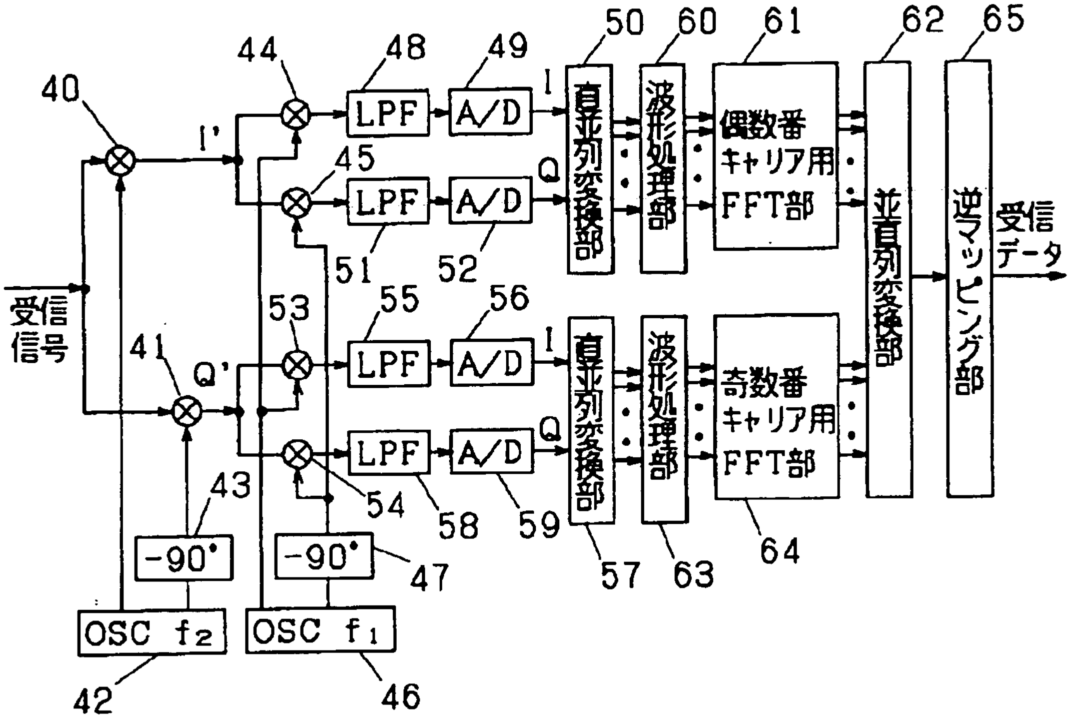
[Drawing 6]


74
Q99, Q101
時間
75
Q97, Q103
時間
76
Q95, Q105
時間
77
Q1, Q199
時間
OFDMシンボル期間Ts

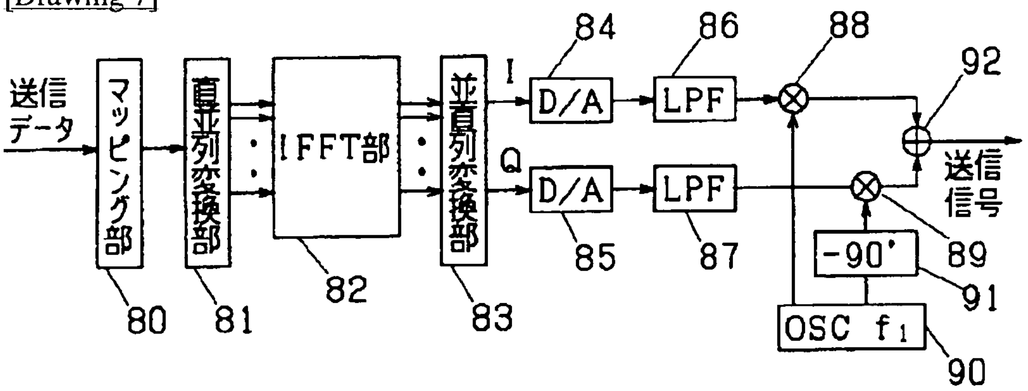
[Drawing 8]


q (直交軸)
1
44
(01)
43
(00)
$\frac{1}{\sqrt{2}}$
-1
1
I (同相軸)
(11)
46
(10)
45
-1

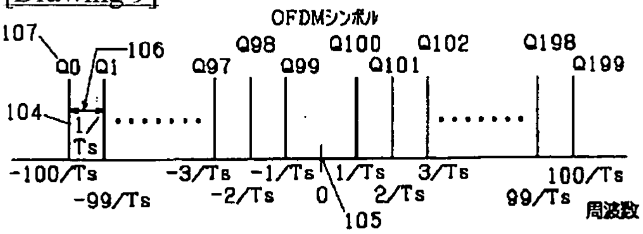
[Drawing 4]


40
44
48
49
50
60
61
62
65
I'
LPF
A/D
I
Q
直並列変換部
波形処理部
偶数番キャリア用FFT部
並直列変換部
逆マッピング部
受信データ
45
51
52
受信信号
53
55
56
41
Q'
奇数番キャリア用FFT部
54
58
59
43
-90°
-90°
47
57
63
64
OSC f2
OSC f1
42
46

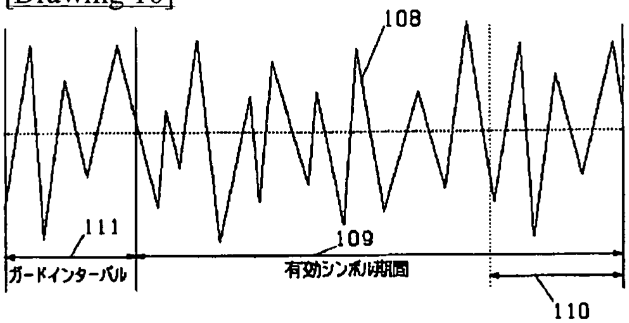
[Drawing 7]


送信データ
マッピング部
直並列変換部
IFFT部
並直列変換部
I
Q
D/A
D/A
LPF
LPF
84
86
88
92
送信信号
-90°
OSC f1
80
81
82
83
85
87
89
91
90

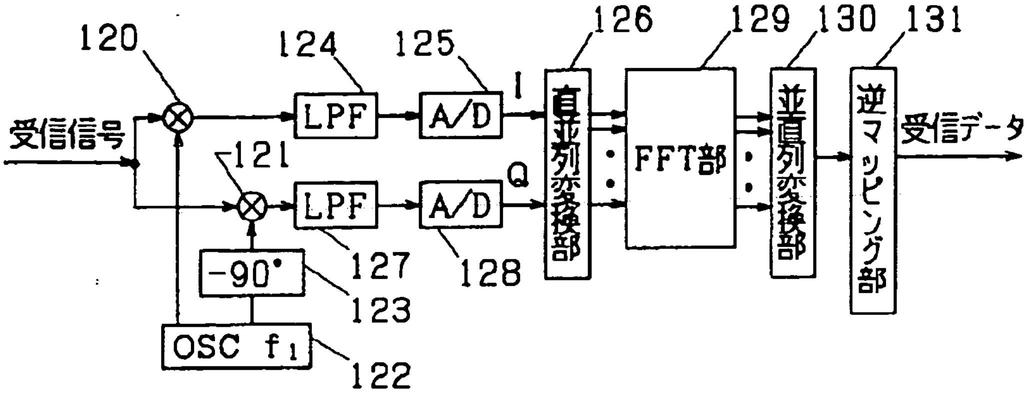
[Drawing 9]


OFDMシンボル
107
Q0
Q1
106
Q97
Q98
Q99
Q100
Q101
Q102
Q198
Q199
104
1/Ts
-100/Ts
-99/Ts
-3/Ts
-2/Ts
-1/Ts
0
1/Ts
2/Ts
3/Ts
99/Ts
100/Ts
105
周波数

[Drawing 10]



[Drawing 11]


120
124
125
126
129
130
131
受信信号
LPF
A/D
I
直並列変換部
FFT部
並直列変換部
逆マッピング部
受信データ
121
LPF
A/D
Q
127
128
-90°
123
OSC f1
122

[Translation done.]

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CORRECTION OR AMENDMENT

[Kind of official gazette] Printing of amendment by the convention of 2 of Article 17 of Patent Law
[Section partition] The 3rd partition of the 7th section
[Publication date] April 20, Heisei 13 (2001. 4.20)

[Publication No.] JP,8-97798,A
[Date of Publication] April 12, Heisei 8 (1996. 4.12)
[Annual volume number] Open patent official report 8-978
[Application number] Japanese Patent Application No. 6-229126
[The 7th edition of International Patent Classification]

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H04J  11/00
H04L  27/34
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[FI]

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H04J  11/00         Z
H04L  27/00         E
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[Procedure revision]
[Filing Date] February 29, Heisei 12 (2000. 2.29)
[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] 0010
[Method of Amendment] Modification
[Proposed Amendment]
[0010] Drawing 10 is an explanatory view explaining the conventional guard interval. As for an effective symbol period and 110, the transmission wave form corresponding to one OFDM symbol Qk in 108 and 109 are [the posterior part of an effective symbol period and 111] guard intervals among drawing. Time Division Multiplexing of the same thing as about 20% of part 110 of the posterior part of the effective symbol period 109 of the transmission wave form corresponding to one OFDM symbol Qk is carried out so that it may be inserted in the guard interval 111 preceded with the effective symbol period 109 as a dummy signal. In addition, this Time Division Multiplexing is performed by the parallel series transducer 83 after processing in the IFFT section 82. The guard interval 111 is set up so that the signal which is overdue and comes according to the multi-pass active jamming in a transmission line at the time of reception may arrive at the period of this guard interval 111, and a recovery performs about the effective symbol period 109 except this guard interval 111 so that it may mention later.
[Procedure amendment 2]
[Document to be Amended] Specification
[Item(s) to be Amended] 0011
[Method of Amendment] Modification
[Proposed Amendment]
[0011] Drawing 11 is an explanatory view explaining the conventional OFDM demodulator. the inside of drawing, and 120 -- the multiplication section and 121 -- the multiplication section and 122 -- the oscillation section and 123 -- the phase shift section and 124 -- the LPF section and 125 -- for the LPF section and 128, as for the FFT section and 130,

the A/D-conversion section and 129 are [the A/D-conversion section and 126 / the serial/parallel-conversion section and 127 / a parallel series transducer and 131] the reverse mapping sections. The input signal of OFDM should be inputted into the multiplication section 120 and the multiplication section 121, multiplication should be carried out to the output of the oscillation section 122 in the multiplication section 120, and the phase shift should be multiplication-carried out -90 degrees in the output of the oscillation section 122 by the phase shift section 123 in the multiplication section 121. The output of the multiplication section 120 is inputted into the serial/parallel-conversion section 126 as an I signal through the LPF section 124 and the A/D-conversion section 125 which are a low pass filter. The output of the multiplication section 121 is inputted into the serial/parallel-conversion section 126 as a Q signal through the LPF section 127 and the A/D-conversion section 128. The output of the serial/parallel-conversion section 126 is inputted into the FFT section 129, a fast Fourier transform is performed to it, it is inputted into the serial/parallel-conversion section 130, serves as a serial signal, it is inputted into the reverse mapping section 131, and received data are obtained. Be [what is necessary / just although the block of the FFT section 129 carries out DFT, i.e., the digital Fourier transform,], FFT, i.e., a fast Fourier transform, is usually used.
[Procedure amendment 3]
[Document to be Amended] Specification
[Item(s) to be Amended] 0025
[Method of Amendment] Modification
[Proposed Amendment]
[0025] Drawing 3 is an explanatory view explaining arrangement of the rectangular carrier to which an OFDM odd number symbol is assigned. The carrier signal of plurality [34] and 35 are the QPSK symbols Qk corresponding to each carrier signal in 37 corresponding to frequency spacing in center frequency and 36 among drawing. The axis of abscissa of a drawing expresses a frequency shaft, and an axis of ordinate expresses amplitude level. Ts is, transmitting spacing, i.e., the OFDM symbol period, of an OFDM symbol. The carrier signal 34 is arranged from **1/Ts by 36 focusing on center frequency 35 at the right and left from spacing 2/the frequency spacing -99 of Ts/Ts to 99/Ts. In this example, the number of the carrier signals 34 is 100, and, as for the QPSK symbol Qk37, from Q1 to Q199 is assigned corresponding to each carrier signal 34. Frequency spectrum when digital modulation of each rectangular carrier is carried out with complex data like the conventional technique and digital modulation of each rectangular carrier is carried out serves as the so-called sinx/x type of curve, and is set to 0 in a midpoint with the frequency point of a contiguity carrier, and the frequency point of a contiguity carrier.
[Procedure amendment 4]
[Document to be Amended] Specification
[Item(s) to be Amended] 0029
[Method of Amendment] Modification
[Proposed Amendment]
[0029] Be [what is necessary / just although reverse DFT is similarly carried out about the block of the IFFT section 4 for No. odd carriers], in this one example, IFFT is used and the reverse fast Fourier transform which is 256 points is performed. In this one example, an OFDM odd number symbol is assigned to 100 points among 256 points, the QPSK symbol corresponding to the remaining point sets to 0, and the rectangular carrier corresponding to this is not transmitted. In addition, the odd-numbered QPSK symbol for a synchronization etc. may be added, and the QPSK modulation of the rectangular carrier which corresponds by this may be carried out.
[Procedure amendment 5]
[Document to be Amended] Specification
[Item(s) to be Amended] 0038
[Method of Amendment] Modification
[Proposed Amendment]
[0038] It is changed into the complex series-connected-type-type data Qk which an OFDM even number symbol and an OFDM odd number symbol are unified in the parallel series transducer 62, and constitutes an OFDM symbol, and the same received data as the original transmit data are obtained in the reverse mapping section 65.
[Procedure amendment 6]
[Document to be Amended] Specification
[Item(s) to be Amended] 0043
[Method of Amendment] Modification
[Proposed Amendment]
[0043] Drawing 6 is an explanatory view explaining the wave of the OFDM rectangular cross carrier of No. odd. The

wave as which 74 express the rectangular carrier of the QPSK symbols Q99 and Q101, the wave as which 75 expresses the rectangular carrier of the QPSK symbols Q97 and Q103, the wave as which 76 expresses the rectangular carrier of the QPSK symbols Q95 and Q105, and 77 are the waves showing the rectangular carrier of the QPSK symbols Q1 and Q199 among drawing. An axis of abscissa expresses the OFDM symbol period which is time amount and is 1 time-slot time amount Ts, and an axis of ordinate is amplitude level.

[Translation done.]